"PUSH THE EDGE OF SCIENCE FORWARD."
EXPANDING CONSIDERATIONS OF EXPERTISE THROUGH SCIENTISTS' CITIZEN SCIENCE WORK IN CONSERVATION

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Despite increases in both the prevalence and acceptance of citizen science in ecology, conservation, and other research contexts, participating scientists can face tough professional questions about their work. These can manifest when undergoing review of journal articles or grant applications; in decisions regarding tenure and promotion; or in negotiating management actions. Such questions may focus on the usability of data collected by non-scientists, the investment of time in non-research activities such as education, and in some cases their (actual or perceived) engagement in advocacy.

What, therefore, makes citizen science possible for these individuals as career scientists, despite such risks? The explosion of citizen science invites questions about why and how scientists work within, or around, the normative traditions of both appropriate scientific research and appropriate public engagement. If we ask only about what researchers should – or even can – do, we run the risk of overlooking what they are *doing in spite of normative expectations.*

We turn to scientists’ stories of practice, rich with action and with meaning, to explore and learn from the kinds of work that scientists are actively undertaking in conservation and natural resource management contexts. These stories bring attention to what scientists are doing, as well as to what individual scientists find meaningful enough to inspire, encourage,

and sustain their participation in what can be considered a risky and contentious career choice. Through this work, we aim to provide the wider community of scientists – potential participants, peer reviewers, supervisors, and colleagues – with visions of the kinds of research opportunities and outcomes that are possible through citizen science partnerships. We also aim to broaden and inform the conversation about what "counts" as appropriate practice for scientists engaging with the public, through citizen science as well as through other means. In doing so, we draw on literature that offers broader considerations of expertise and credibility, and discuss social and relational dimensions of these concepts that we can recognize and begin to appreciate in the work of professional scientists.

BIOGRAPHICAL SKETCH

Jennifer is a native Pennsylvanian who got her start in citizen science through an Earthwatch scholarship, as a high school student, to join a research expedition studying sea turtles in Mexico. From that experience, she has woven together a career involving herpetological research, environmental education, conservation, and citizen science.

Jennifer has a B.A. in Conservation Biology from Bard College, where she completed a Senior Research Project investigating the migration patterns and body temperatures of mole salamanders in a New York vernal pool. She has also studied salamander populations in Shenandoah National Park and throughout Northern Virginia, work that she carried into graduate studies. Her M.S. in Natural Resources, from Cornell University, looked at salamander monitoring initiatives on or near school grounds, investigating potential impacts on data quality and learning when high school students asked and answered their own research questions.

Prior to her graduate work, Jennifer also worked in environmental and conservation education, at Penn State's Shaver's Creek Environmental Center, Catalina Island Marine Institute, and the Smithsonian's Conservation and Research Center (now called the Conservation Biology Institute).

Jennifer currently works with the Cornell Lab of Ornithology's Department of Program Development and Evaluation to support effective citizen science project design and management. Since 2006 she has served as Project Leader for the website *CitizenScience.org*, and from that vantage point has worked with organizations including the Association of Science-Technology Centers and 4-H to provide resources and opportunities for all who lead, manage, implement, and research citizen science projects.

Jennifer has helped coordinate major networking events for the field, including the 2012 PPSR Conference in Portland, Oregon and the 2011 Workshop on Engaging and Learning for Conservation, and the 2007 Citizen Science Toolkit Conference. She has also contributed to landmark documents including the 2009 inquiry report on informal science education outcomes of Public Participation in Scientific Research (funded by the National Science Foundation's Center for the Advancement of Informal Science Education). In collaboration with colleagues from a wide range of institutions she is helping to lay the groundwork for a new Citizen Science Association.

In 2004, after finishing her Master's degree, Jennifer hiked the Appalachian Trail from Mount Katahdin in Maine to Springer Mountain in Georgia. She serves on the Board of Greensprings Natural Cemetery in Newfield, New York, where she has lived with her husband, dogs, and a cat since 2009. Shortly following the completion of this dissertation, she will return to Maine with her husband for a 10-year anniversary hike of 160 miles of Maine woods along the Appalachian Trail.

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My colleagues at the Lab of Ornithology have been an important part of my professional growth and life at Cornell. I feel privileged to be working with the team in Program Development and Evaluation – Tina Phillips, Jody Enck, Norman Porticella, and Marion Ferguson – as well as many others. Here again, I am forever grateful to Rick Bonney for his unwavering support, encouragement, and friendship throughout my process of developing as a researcher and as a professional in this field.

I have found inspiration in the rapid growth of the citizen science field over the ten years that I have worked on this research, and the field itself has become another professional home to me over that time. In addition to those previously mentioned, and others too numerous to name, a few individuals I've had the pleasure and honor to work closely with and learn from include Heidi Ballard, Abe Miller-Rushing, Meg Domroese, Andrea Wiggins, Greg Newman, Sandra Henderson, and Darlene Cavalier.

The graduate student community at Cornell, particularly in the Department of Natural Resources, may be unsurpassed in its collegiality. In my most recent years I have been buoyed by both personal and intellectual support (and commiseration) from Alex Kudryavtsev, Laura Martin, Taza Schaming, Laura Eierman, and Philip Silva, but many others have come before and many rising students who I've missed getting to know better as I've moved off of main campus. I could not have endured the process of the dissertation without the years of friendship, ice cream, conversation, and encouragement offered by Kendra Liddicoat and Brian Barringer.

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My most invaluable support has come from my family, and I offer particular thanks to my husband, Sam Hernandez, and my parents, Joan & Ray Shirk, for inspiring me in more ways than I can enumerate here.

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CHAPTER 1

“SOMETHING ELSE GOING ON HERE.” INVESTIGATING THE INVOLVEMENT OF SCIENTISTS IN CITIZEN SCIENCE

ABSTRACT

Much of the success of citizen science and other forms of public participation in scientific research would not be possible without the involvement of scientists. Although more and more scientists are engaging with the public through such partnerships, researchers choosing this path may find their work contested, encountering questions about data accuracy or bias. Citizen science work is also complex, often demanding unexpected dedicated time and money, as well as an atypical skill set. Prevailing theories as to why researchers engage with citizen science – such as to access new data for publications or to satisfy broader impacts criteria – seem overly simplistic in comparison to related challenges. Tensions can be heightened in contexts of conservation and natural resource management, where science at times holds a contentious position in regards to complex social-ecological concerns.

As citizen science is still a relatively new field of practice, scientists may encounter new challenges to recognize, articulate, and balance both scientific and civic commitments. Stories of practice reveal scientists’ nuanced considerations of appropriate roles for scientists in public life. These stories offer insights to scholars of citizen science (and related endeavors) upon which a research agenda can be constructed to better understand this field of practice and the civic-minded work of scientists. Additionally, stories may help other scientists see new possibilities and strategies for expanding their own work in citizen science, and/or acknowledging the work of others who are involved.

In this introductory chapter I: 1) introduce the practical and academic contexts for this research; 2) present an overview of the chapters included in this dissertation; and 3) provide some methodological background regarding the narrative approach I bring to this work. I make a case for the timeliness of this research, given the rapid expansion of citizen science and its potential to address pressing conservation concerns. I conclude by inviting readers to reflect on the broader relevance and applicability of this work in other fields where researchers may choose to engage with the public.

INTRODUCTION

Why might scientists invite members of the public to become significant contributors to conservation research? Julia Parrish at the University of Washington runs a citizen science project called the Coastal Observation and Seabird Survey Team, or COASST, involving volunteers in monitoring beaches for dead birds to investigate population and mortality trends. She described her initial vision for the project in this way: "I thought about it as a Huck Finn[1] paint-the-fence thing."

Julia Parrish's 'Huck Finn' comment could be read as an instrumental, technical, intention, especially as she goes on to say, "I knew what I wanted – I wanted more regional information about this one bird, the Common Murre." Such an interpretation aligns with prevailing assumptions that scientists pursue citizen science primarily to access data for publications. But this assumption seems overly simplistic to account for a scientist's investment in citizen science, particularly in the socially complex realm of conservation and environmental management. In fact, as Julia shares the story of her evolving work with COASST, we can start to see that she brings other considerations and commitments to this work. She continues with a reflection on her 'Huck Finn' days of the program:

> *I think, at the time, I still was pretty steeped in thinking about it from my own point of view and the kinds of data that I wanted. And I wasn't really thinking about what the experience of the participant would be. That only came later, when participants started to tell me what their*

[1] Although Julia uses the name Huck Finn (and I continue the use of this name in this chapter), the story she refers to is about Mark Twain's character Tom Sawyer.

> *experience was, and it made me think, "huh, there's something else going on here besides just helping out a scientist."*
>
> … *Citizen science, I have come to learn, is not just about people doing science, it's about people doing science connected to a place or a thing that they love. And if you break that connection, they become the kid in school again. So my experience has been that you have to find that connection, and then you have to celebrate it. And then people will stay with you for a very long time.*

By listening to the stories scientists tell about their work, we can come to learn surprising things. Unlike Huck Finn, who was less interested in the task at hand than in putting the task behind him, this story helps us see that for Julia (and, we suggest, likely other scientists) there may also be, "something else going on here," beyond scientists simply pursuing more information for research.

As one example, in the excerpt above we can see Julia's thinking expand about her work with the public – from presuming that recruiting volunteers is a viable way to do research, to a view that celebrating personal connections to place is a necessary and valid part of that pursuit. Might an interest in data still be an important element? Of course. But we suggest that, like Julia, scientists may be guided in their citizen science work by theories that are more complex and nuanced than the technical pathways to conservation often presumed to be "normal" for scientists. We also anticipate that in the process of sustaining research partnerships, these scientists are seeing new possibilities for science and conservation, and that to achieve them they may take up new and unexpected roles in relationships with the public. To learn more about these critical but underappreciated aspects of scientists' citizen science work, we invited scientists to tell us their stories.

BACKGROUND

I came to this area of inquiry in the midst of increasing attention to citizen science. In 2006, the National Science Foundation funded an invitational conference, which I helped coordinate, to compile best practices for developing and leading citizen science projects. This funding came within the context of informal science education, but with an understanding that the unique learning that happens through these partnerships is dependent upon involvement in rigorous, real-world science. From my previous work investigating student-scientist partnerships (SSPs; citizen science for schools) I understood that that scientists are critical partners in facilitating both the learning and the science, but my experience and the SSP literature suggested that those partnerships are incredibly difficult for the scientists involved.

It was clear that the critical roles of scientists were poorly understood, let alone the thinking that would draw them to (and sustain them in) these partnerships as part of their professional scientific careers. The prevailing assumption as to why they would get involved – the need for otherwise inaccessible, publishable data – seemed too simplistic to account for the few resulting publications and the challenges they were likely facing. Scientists maintained commitments to SSPs such as GLOBE, for example, despite well-documented difficulties of these partnerships to produce peer-reviewed publications. Other scientists, I knew, were conducting cutting-edge research through citizen science, but were receiving little or no recognition for the complex and intensive coordination and analysis work they were doing to establish and maintain large, publicly-generated datasets. And I had some awareness of scientists who were advancing citizen science with an interest in specifically addressing problems, such as water quality. I therefore began this research with a suspicion that traditional outcomes associated with "scientific success" – such as numbers of publications, tenure, and grants received – may not be all that is meaningful to the scientists involved.

As one potential dimension of this, I suspected that individual scientists in these projects might be more interested in and sensitive to civic and social dimensions of their science than is generally expected of professional researchers. And yet in the vast majority of projects in conservation contexts, I could see the larger community of scientists struggling to address "wicked problems" – complex social-ecological and social-technical problems that Groffman et al. (2010) and others described as demanding new, more socially-engaged roles of scientists. From my experience in the field of citizen science, specifically in conservation contexts, I suspected that science researchers pursuing citizen science were encountering tensions that were prompting creative reframing of their roles in relationship to both the professional and public spheres.

In 2006, at the time of the conference, we estimated that there were perhaps 200 citizen science projects, and my attempts then to find scientists dedicated to this work turned up in the realm of 30 – at the time, that seemed like a dramatic increase in this practice. At the time of writing, citizen science work is being undertaken on every continent, with peer reviewed papers estimated in the thousands and professional associations springing up to support this growing field of practice. The work of scientists in this field is here to stay. And yet, as citizen science is still a relatively young field of practice, scientists often engage in such partnerships without role models, mentors, or theories to guide their work (Meyer et al 2010, Kainer et al 2009, Teufel-Shone 2011). There is a need for more attention to why and how scientists effectively pursue and sustain their work with citizen science.

With this research, I aim to bring attention to the underappreciated work and sustaining commitments of scientists in this relatively new and growing field of practice. I began this research with an interest in understanding why science researchers choose to – and how they go about their – work with volunteers, as well as the circumstances and understandings that allow them to sustain that work despite challenges. These interests crystallized around how researchers understand and pursue citizen science related to conservation problems. The data – storied insights from scientists deeply engaged in this work – further focused my attentions towards the unexpected outcomes and roles scientists were articulating as meaningful and in some cases essential aspects of their practice. Beyond the questions I pose and explore in the following chapters, the resulting stories of the scientists themselves offer both instructive practical guidance and theoretical insights for this growing field of practice.

RESEARCH CONTEXTS AND QUESTIONS

Citizen science and public participation in scientific research

When I began this research in 2005, the definition and scope of the term "citizen science" was (and arguably still is) contested. Working at the Lab or Ornithology, birthplace of the term in the United States as referring to large-scale scientific investigations (e.g., Bonney et al. 2009*a*), I was part of a conversation that was defining citizen science in relationship to scientific outcomes. I was also reading Alan Irwin's book entitled, "Citizen Science: A Study of People, Expertise and Sustainable Development," (1995) concerning public engagement in environmental governance and policy. At the time I didn't specifically see my research frame expanding to include the work Irwin described, but I did have an interest in initiatives that paralleled the Lab of Ornithology definition but that went by different names: volunteer monitoring, community forestry, and participatory monitoring, just to name a few.

My research is therefore positioned in the broader context of public participation in scientific research (PPSR), "intentional collaborations in which members of the public engage in the process of research to generate new science-based knowledge" (Shirk et al. 2012). I was part of the team that coined this term (see Bonney et al. 2009*b*) as a means of understanding a wide range similar project types and practices. The term PPSR may not persist, as the acronym is awkward and in the intervening years there has been a popular adoption and expansion of the term citizen science. In my later chapters, in fact, I return to the use of the term citizen science, and my concluding chapter offers an explicit invitation to consider a broader definition of that term. But for a time "PPSR" has offered a defined umbrella under which I can investigate many ways in which scientists choose to engage with the public around the process of research.

Chapter 2, ***Public Participation in Scientific Research: a Framework for Deliberate Design****,* uses the term PPSR as a springboard for exploring the literature for the range of ways in which scientists might engage with the public in scientific research. I review the work of other scholars to outline five models of PPSR, based on different research relationships between scientists and the public. I also present a framework that suggests that interactions between scientists and the public can affect not only the design of a given project and participation model, but also the range of social and scientific outcomes that might result.

As scientists are influential partners in the design of many projects, this chapter opens the door to questions about the factors that effect different participation strategies pursued by individual scientists. What are the types of goals and interests that these individuals might bring to the design of projects, and in what ways could they bring those into conversation with the public? What means of engagement do different scientists see as possible and/or appropriate in given contexts? How can we better understand the kinds of thinking and circumstances that might influence or enable scientists' choices regarding participation? And how can we look beyond assumptions that scientists are either detached or exploitative, to recognize the intentions and practical theories they bring to their citizen science work?

Conservation

To pursue these research ideas, I chose to focus my inquiries in the context of conservation. At the time in which I began my research, the vast majority of known citizen science projects were situated in conservation or environmental management contexts. My choice of focus wasn't purely pragmatic – there were certainly a number of projects in astronomy, for example, that I could have included in this work. Rather, the preponderance of conservation projects begged the question of what might be unique about this context. It also offered a hypothesis – that scientists in conservation fields may be seeing and responding to unique needs that collaborative research approaches might address.

One of those needs arguably is the nature of certain large-scale conservation problems and the opportunity to address those problems through the work of distributed observers. This rationale for citizen science has, in the interim, been documented and described in a number of recent papers (e.g., DeVictor 2010, Sullivan et al. 2009), and it did emerge as one motivating or enabling factor for several scientists I spoke with in my research. But the conservation literature has begun to suggest an additional, more provocative and more complicated, possibility: scientists are realizing that scientific knowledge alone is insufficient to address complex social-ecological problems (Palmer et al. 2005). Given that technical knowledge is what scientists are trained to produce, scientists in problem-focused fields such as conservation may therefore grapple with whether and how to bridge the gap between technically-focused research and socially-embedded conservation action (Laurance et al. 2012, Groffman et al. 2010, Robinson 2006).

In chapter three, ***"Something else needed to happen." Experts, judgment, and the conservation possibilities of citizen science***, I examine the stories of practice of nine scientists to answer the following questions: 1) what kinds of conservation outcomes do individual scientists imagine are appropriate and possible through citizen science? And; 2) how do these individuals describe the pathways by which citizen science might facilitate those outcomes? I respond to cautions from the participation theory literature that presume scientists have primarily instrumental aims when partnering with the public, and explore the possibility that these scientists may be working towards more integrated social-ecological goals.

In the stories of these individual scientists we do see indications of interests in outcomes and pathways that acknowledge the complex and often social nature of conservation problems. They show us that they understand some social outcomes to be within their reach, not outside of their purview. Their stories show us possibilities as to how scientists can pursue socially complex conservation objectives not *instead* of their science, but *through* their science. And they invite us to consider how scientific experts in any field can effectively exercise judgment in pursuit of socially-minded outcomes (per Sullivan 1995), through pathways that seek to engage not just public participants but also public interests.

Public engagement

Recognizing such possibilities raises new questions about what it looks like when scientists begin to pursue more publicly engaged research. Across many scientific disciplines, engagement in the form of communication and public education seems to be increasingly (if reluctantly) recognized as, "a key and unavoidable component" of scientific careers (Cheveigne in Jensen et al. 2008). This reluctance is driven, in part, by historical and theoretical understandings of scientists' roles in public life that establish clear, normative boundaries around science as a technical practice and scientists as technical experts. These norms often discourage, if not exclude, scientists from bringing their expertise into conversation with the public or into the service of complex problems that touch on values or politics (e.g., Whitmer et al. 2010, Peters et al. 2008). Thought leaders in conservation (and in other disciplines) are calling upon scientists to find new ways to bring their science into intersection with societal concerns. In doing so, they acknowledge that this will challenge traditions and cultures of scientific work, and demand new considerations of the roles scientists play in public life (Groffman et al. 2010, Leshner 2007, Palmer et al. 2005).

Citizen science, as one potential example of more civically engaged research, can invite scientists to venture into roles that have often been considered off-limits – particularly roles that bring scientists to engage complex social-ecological challenges. Scientists doing publicly-engaged work may be called upon to make new, often uncomfortable, and potentially contentious decisions regarding their role as civic actors within a sphere that has traditionally drawn sharp boundaries around what it looks like to undertake a career in scientific research (e.g., Sullivan 1995, Fischer 2000).

In chapter four, ***"I try to work with these people." Scientists, citizen science, public engagement, and conservation***, I ask: what kinds of roles do scientists take up in their projects, in their professions, and in their relationships with public volunteers? Stories of practice show individual scientists embracing unexpected and diverse roles – such as Activist, Mediator, and Network Broker – that demonstrate different ways of engaging social aspects of conservation. Their stories show us ways that these additional roles can at times enable, rather than confound, their science. They also offer an opportunity to think critically about how professional ideals that emphasize technical considerations, such as "credibility," can be complimented rather than threated by relational attributes such as "saliency" and "legitimacy" (e.g., Cook et al. 2013).

A developing field of practice

As we start to see scientists integrating social and scientific practices for conservation, this can lead us to ask about the lines that are drawn around different aspects of citizen science as a growing field of practice. There are confusing, and seemingly competing, definitions, such as the aforementioned usages offered by Bonney and Irwin. Irwin's conceptualization of citizen science does expect, and even demand, scientists' direct engagement with social and political concerns, intentionally challenging the detached norms of institutionalized scientific practice (1995). Citizen science in the US to date has been cast in a bit of a "safer" stance for scientists, emphasizing public participation in the process of scientific research (Bonney et al. 2009*a*).

Work is underway to establish a professional association for citizen science (Benz et al. 2013), a move that will force the question of what "counts" as citizen science practice for scientists and others. In my concluding chapter, ***"Make science relevant." Citizen science and the multiple dimensions of scientific practice***, I invite consideration of differing definitions, and also shine a light on ways scientists (whether practitioners of citizen science or peer reviewers of citizen science work) are being told what is possible through citizen science. Because this field is relatively young, it is our experience that scientists engaged in citizen science have few opportunities to learn from others in similar positions as to how to approach, consider, conduct, and review this type of work, let alone how to define it. A dispersed body of peer-reviewed literature that variably talks of citizen science as research, education, or a compromised trade-off between the two likely does little to help clarify the issue for scientists.

I draw on the work of the previous chapters, as well as a few brief summaries of scientists' stories, to offer a more nuanced picture of the multidimensional possibilities scientists might pursue through citizen science. These stories can provide us with new ways of thinking and talking about citizen science, breaking out of traditions and limiting considerations of distinct rather than synergistic outcomes. This has implications for both individual scientists and for citizen science as a developing field of practice.

Another research product of this dissertation is a compiled set of scientists' stories of practice. Through these stories, we can begin to recognize, appreciate, and (I optimistically suggest) make a space for the human elements that scientists can bring to the conservation equation, to begin to move collaboratively beyond solely technical approaches to addressing complex problems.

NARRATIVE RESEARCH

The practical and the scholarly work of these chapters were possible because of the unique nature of narrative research. Narrative provides a means of seeking insights through storied accounts of events, in a way that Ospina and Dodge (2005*a*) suggest, "... directs attention to questions about what it means to interpret and experience the world (rather than explain or predict it)." This research approach has become increasingly accepted and implemented within a wide and growing range of academic disciplines and professions pursuing practice-focused scholarship (Chase 2011, Spector-Mersel 2010), in part because narrative can yield both theoretical insights to inform scholarship and practical insights that can guide the work of practitioners. Narrative research is well suited towards the research questions I am posing, about how practitioners ascribe meaning to work, draw upon practical theories in design, and understand their identities in professional practices.

My third and fourth chapters provide descriptions of the methods I used to invite and analyze scientists' stories. Here, I take the time to also share some of the *why*, as well as some of the *how* of narrative research, in more depth than these chapters accommodate.

Why narrative?

There has been a "narrative turn" (Riessman 2008) in research traditions that may be evident only to scholars in certain circles. But many in this country may be familiar with a similar surge of attention to stories, through initiatives such as StoryCorps and radio programs like This American Life. Stories are a uniquely human way of making sense of the world, and are a strategy that people everywhere employ naturally and irrepressibly (Yang 2013, Chase 1995). Our urge to share stories of events and experiences is not frivolous, however. StoryCorps founder Dave Isay, when asked after more than a decade of collecting stories whether he had seen trends in story themes change, shared that regardless of the time or place, when people take the time to tell a story, "they talk about the things that matter" (Isay 2013).

Stories are a natural and powerful currency of communication. As units, stories have dimensions of time, plot, action, and intention, and they organize thought among those dimensions (Yang 2013, Ospina and Dodge 2005*a*). The temporal dimension of stories, in particular, allows us to see events and ideas unfold, change, and evolve (Ospina and Dodge 2005*a*, Clandinin and Connelly 2000). Stories also allow us to describe things that we may not directly see, but imagine are possible (Palmer 2012). They represent a skill that we have arguably honed through eons of evolution as we strive to convey information and to be understood (Yang 2013).

Forester (1999, p.29) helps us see that stories, "... are not just idle talk; they do work... by organizing attention, practically and politically, not only to the facts at hand but to why the facts at hand matter." People tell certain kinds of stories in certain kinds of ways both because of how they understand the world and – perhaps more importantly – how they want to be understood in terms of their identities, agendas, and choices. As just one relevant example, people often rely on stories to process their actions and to explain and/or justify (to themselves and others) why they continue to be involved in activities that are risky, challenging, or complicated (Chase 1995, see also Moore et al. 2005).

A growing body of scholarship is being built on the premise that there is relevant learning that can be accomplished through a thoughtful consideration of practice, and from inviting practitioners to reflect on the meaning of their work (Forester 2006, Ospina and Dodge 2005*a,b*). Scholars are looking to stories to help reveal the meaning and significance individuals find in, and bring to, professional practice in fields from education and psychology to business and law. Recently, attention has also turned to stories of the experiences and work of scientists (Leslie et al. 2013, Johnson et al. 2014).

Narrative research, the rigorous pursuit of insights and knowledge through stories, aligns well with practice in part because it seeks not to explain, but to understand (Ospina and Dodge 2005*a*). Stories can serve as a productive means of facilitating reflexive – and therefore more intentional – practice, an opportunity that many practitioners may have little time to afford themselves (Ospina and Dodge 2005*b*). Through stories, practitioners can give voice to things that are implicitly known but seldom perceived as important and therefore seldom discussed, things such as imagined possibilities and practical theories (Ospina and Dodge 2005*b*). These aspects of stories can help to bridge the divide that often exists between research and practice, a concern shared not just by social science scholars of practice but also by the field of conservation (Ospina and Dodge 2005*b*, Robinson 2006).

By understanding what stories have to offer, we can start to think about their potential for addressing questions and concerns that can't be pursued through other types of research.

Underlying assumptions

Conducting research with stories can call for reflection on the ontological (the nature of what can be known), epistemological (the relationships between the knower and the known), and methodological (how we *apprehend* what can be known) assumptions about the nature and pursuit of knowledge. In the natural sciences, we are accustomed to research that presumes a knowable and immutable reality, expects that researchers are objective and unbiased, and that proceeds by controlling, experimenting, and quantifying in order to explain, generalize, or predict (Guba and Lincoln 1998, Spector-Mersel 2010).

But counting and predicting are not the only ways that we can inquire and learn about phenomena. Spector-Mersel (2010) calls attention to narrative inquiry as a distinct paradigm, albeit one that is broad and diverse. Ontologically, narrative research is attentive to the knowledge embedded in stories, and assumes that narrative is the foundation of social reality (Spector-Mersel 2010). Epistemologically, the knowledge gained from stories is both subjective and transactional (Guba and Lincoln 1998), where what is known is dependent on the meaning(s) interpreted and even re-interpreted differently by different listeners, as well as how listeners may influence the story that is told (Wells 2011, Riessman 2008). Methodologically, narrative research pursues knowledge through stories, and situates storytellers (in the case at hand, practitioners/scientists) as co-producers of that knowledge (Ospina and Dodge 2005*b*).

Narrative research shares many key strengths and ideals of natural science. It is arguably a process of developing theory based on critical analysis of empirical evidence (in the case of narrative, “linguistic” observations) (Schiff 2006). While some uphold narrative research as a form of science (e.g., Wells 2011), narrative, interpretive work does not aim to predict, prove, or generalize (Pinnegar and Daynes 2007). Peters and Franz (2012) see instead that narrative, “.... is (or can be when done well) a valuable approach to incorporate into the work of learning and discovery *precisely because it isn't scientific.* A narrative approach to teaching and research taps into a way of knowing that is different from science” (emphasis in the original).

In this sense, narrative research can be quite pragmatic. Forester (1999, p. 25) notes that, “... in practice, the real-time demands of work allow for little systematic experimentation,” and that, “in practice situations we find stories and more stories, told all the time and interpreted all the time ... but we find relatively few ‘controlled experiments.’” He reflects that the types of knowledge that can be gained through learning from practice are in line with what is needed:

> *... not abstract lists of ‘what worked,’ but specific stories of reconstructive action—not so much experimental results but experimental stories, not so much or only abstract rules (or principles alone) about 'what to do' but emotionally rich, morally entangled, contextually specified stories about ‘how they really did it.’*

Knowledge from narrative research elucidates rather than explains; it helps reveal not what is "real," but what is meaningful and possible (Peters 2010). This knowledge of what is (vs. what "should" be) happening enables us to recalibrate theoretical assumptions, inform practice, and bring theoretical and practical work into close conversation (Peters 2010, Ospina and Dodge 2005*b*).

The practice-focused disciplines from which a narrative tradition has emerged have shown openness to this research approach, and have benefitted from it, but they are not immune to critiques from positivist perspectives. Many of these professions (such as education, health, and planning) have recently found themselves facing a political climate that prioritizes, "evidence-based policy and research-funding practices" (Mazzei 2010, see also Head 2010, Lyons 2007, Root and Alpert 1994). It is reasonable to expect that practices (whether in education, medicine, planning, or science) can be informed by thoughtful and rigorous quantitative studies. However, a place for statistics doesn't mean we should discount the complementary value of other forms of evidence, such as stories (Riessman 2008).

This tension begs the question of what *does* count in different fields and disciplines as evidence, as data, as truth, as meaning (Mazzei and Jackson 2009). Part of what has fascinated me about this research process has been the epistemic questions that run in parallel, in both my research context and my research approach: what counts as knowledge? What counts as data? Whose knowledge is relevant? What constitutes a scientific question? While I do not attempt to resolve these questions from an epistemological standpoint, I do appreciate the synergies between the epistemic underpinnings of narrative research and many of the questions facing the field of citizen science.

Validity and quality

Given the subjective nature of knowledge that narrative is well positioned to pursue, how can narrative research be assessed for its quality? In many fields, research is evaluated in terms of "validity," which is often understood as the relationship between reality and the knowledge produced through research. Some scholars raise questions about whether "validity" is the appropriate concept to consider in relationship to research into subjective truths (Dodge et al. 2005, Spector-Mersel 2010). Despite this, there is no contestation among scholars of the need to defend the justifiability of claims based on narrative research.

In any research paradigm, Polkinghorne (2007) proposes that, "judgments about the validity of a knowledge claim depend on the force and soundness of the argument in support of the claim." One straightforward consideration of validity is whether the research effectively reveals the knowledge sought (Kelley 1927 via Borsboom and Mellenbergh 2004). This demands appropriate means of addressing the question at hand (Dodge et al. 2005, Dunne and Pendlebury 2003).

Therefore, attention to validity must be embedded in every facet of a study design, from alignment of goals with design, through reflection on sources of bias and alternative interpretations (Wells 2011, Maxwell 2005). In addition to attending to issues of ethics, rigor, and other criteria of quality qualitative research (Tracy 2010), narrative demands attention to validity regarding two particular concerns related to the dynamic and interactional nature of stories and their interpretations. Per Polkinghorne (2007), these are, "... the differences in people's experienced meaning and the stories they tell about this meaning," as well as, "... the connections between storied texts and the interpretations of those texts" (see also Riessman p. 184). The former concern demands attention to the circumstances of eliciting stories. The latter requires attentiveness to the interpretation and representation of resulting stories and insights (Wells 2011).

Narrative validity thus demands intentional and iterative work on the part of the researcher to establish trust and trustworthiness in eliciting and interpreting stories. Strategies for accommodating this element of narrative research include transparently sharing research aims, attentively negotiating research relationships, and seeking confirmation and clarification of narrative interpretations (Chan 2005, Dodge et al. 2005, Riessman 1993).

Validity also demands reflexivity on the part of the researcher – the willingness to critically examine one's own role in and influence on the research process and findings (Wells 2011). Strategies towards reflexivity include sensitivity to the influence of researcher-interviewee relationships on the stories shared, awareness of the contributions of one's own experiences to the insights generated, seeking additional sources of insight, and considering alternative explanations and interpretations (Wells 2011, Polkinghorne 2007, Dodge et al 2005).

Some scholars argue that an additional testament to the validity of a narrative research endeavor is its ultimate utility in advancing theory and/or practice (Riessman 1993). While difficult to confirm in the near-term, this aspect of validity has moral and ethical dimensions that do need to be attended to within the time frame of the research. This surpasses meeting the standards of institutional ethical review boards. We of course have a moral obligation to represent the work of these individuals with dignity and respect (Peters 2010). But we also have an obligation to honor the time and insights they have contributed by being thoughtful, and even at times productively critical, in order to advance research that is relevant, and worthwhile (Peters 2010, Ospina and Dodge 2005*b*).

Narrative methods of research and analysis

I asked nine scientists to share their stories about how and why they choose to do this work. I chose to work with scientists who have demonstrated a commitment to the scientific aims of their work as well as a willingness to reflect on their work in relationship to the public. Given the context-specific nature of this research, individuals all consented to be identified on the condition of reviewing and negotiating any materials made public. The research methods and stance described here, including this aspect of identifiability, were reviewed, approved, and ultimately exempted by Cornell's Institutional Review Board for research with human subjects.

In the interviews, I explicitly invited *stories*, not reports (per Peters 2010, Chase 1995), through the use of open-ended prompts such as, "Tell me how you became involved in this work," and, "what happened next?" Details were fleshed out in subsequent interviews with requests to share experiences and fill in the gaps (Chase 1995), along the lines of, "how did that come about?" and, "tell me what inspired that track."

I follow the work of Peters, Forester, and colleagues in constructing and interpreting "practitioner profiles" from resulting interview transcripts (Peters 2010, Forester, Peters, and Hittleman 2005). I refer to the resulting documents as, "stories of practice," after encountering some confusion among interviewees over the term "profile." The final stories of practice are themselves a major product of this research.

I do both "narrative analysis" and "analysis of narratives" (per Polkinghorne 1995 via McCormack 2005). The former includes the construction of a story from compiled data – in my case, constructing coherent stories of practice from multiple interview transcripts. I pursued the analysis of narratives – working with compiled stories – through an iterative process of reflecting upon the resulting stories of practice (both individually and in relation to one another), seeking related insights in the literature, through synthetic writing, and via further reflection.

To reflect on the trustworthiness of the meaning conveyed via interviews, I both listened and read for any questions of reliability and credibility – any reason to suspect they would be intentionally telling me a particular version of their experienced meaning. I also sought correspondence between their stories and other evidence related to their practice, including project materials and journal articles (Riessman 1993).

To reflect on appropriate representation of meaning, I asked all interviewees to review and comment on their constructed story of practice (Forester et al. 2005). Clarifications are reflected in the final versions (Appendix A). I also employed strategies such as interrogating claims through reflexive questioning, (e.g., "What are the conditions under which the narrative was produced, and what are the consequences… for interpretation of the narrative's meaning?" from Wells 2011). I also make the full and final stories of practice available to invite additional, even conflicting, interpretations of their meaning and significance (Peters 2010, Riessman 1993).

Throughout this process, I was guided by the practical goal of providing insights, role models, and strategies for peers interested in citizen science. I followed the practical theory of Peters (2010) that, "… appreciative readings of stories of such work can inspire positive change at least as much as – if not more than – critical readings," (p. 316). While I do take a critical look at these interview data, my aim is not to *critique* the scientists I interviewed. Rather, it is my goal to learn from the practice of scientists who have sustained their participation in difficult work, in order to understand complexities as well as possibilities. I aspire to offer any critiques in the spirit of friendship, per Forester (1999):

> *"… we take their [friends'] words to help us to see our own interests, cares, and commitments in new ways as we may come to reconsider, for example, how we rank our interests…. They help us to understand not just how the world works, but how we work, how we are, who we are – including, importantly, what sorts of things matter to us. … they do not typically offer us simplistic cure-alls or technical fixes. They do not explain away, but rather try to do justice to the complexities we face. They do not reduce those complexities to trite formulas… friends recognize complexity, but as pragmatists concerned with our practice; they neither paralyze us with detail nor hide details from us when they know they will matter."*

My agenda is to bring both practical and theoretical attention to the nuanced, complex, and underappreciated work of scientists engaged in citizen science initiatives, to bring more positive attention to, and uphold high standards for, citizen science as a field of practice.

What we gain through narrative

As a final, practical case for narrative, there is value in stories not just in what they can reveal, but also in what they can enable. Hearing a story can provide a point of entry into new practice, as stories can, “engage our emotions and passions” in ways that other texts may not (Forester 1999, p. 35). Readers can find resonance with new ideas and practice, making sense of the thinking behind the action and helping to make the practice itself more achievable.

OPENING THE CONVERSATION

With this work, I aim to broaden the conversation about what is possible, by shining a light on the underappreciated work that is already being done. By opening new windows onto practice, however, this research process will ultimately reveal many more questions than it answers. With the following chapters, this work merely opens a discussion into a previously unexamined area of practice, providing insights upon which we can establish a research agenda. These insights and stories also invite additional perspectives and new questions that other readers can bring to the conversation, towards advancing the practice and scholarship of citizen science as well as this burgeoning field of practice.

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CHAPTER 2

PUBLIC PARTICIPATION IN SCIENTIFIC RESEARCH: A FRAMEWORK FOR DELIBERATIVE DESIGN

From an email dated 2 July 2014 from Adele Mullie, Managing Editor:

The publishers of Ecology and Society would be delighted if Jennifer Shirk included her paper, Shirk, J. L., H. L. Ballard, C. C. Wilderman, T. Phillips, A. Wiggins, R. Jordan, E. McCallie, M. Minarchek, B. V. Lewenstein, M. E. Krasny, and R. Bonney. 2012. Public participation in scientific research: a framework for deliberate design. Ecology and Society 17(2): 29, in her dissertation.

Shirk, J. L., H. L. Ballard, C. C. Wilderman, T. Phillips, A. Wiggins, R. Jordan, E. McCallie, M. Minarchek, B. V. Lewenstein, M. E. Krasny, and R. Bonney. 2012. Public participation in scientific research: a framework for deliberate design. *Ecology and Society* **17**(2): 29.
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Synthesis

Public Participation in Scientific Research: a Framework for Deliberate Design

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ABSTRACT. Members of the public participate in scientific research in many different contexts, stemming from traditions as varied as participatory action research and citizen science. Particularly in conservation and natural resource management contexts, where research often addresses complex social–ecological questions, the emphasis on and nature of this participation can significantly affect both the way that projects are designed and the outcomes that projects achieve. We review and integrate recent work in these and other fields, which has converged such that we propose the term public participation in scientific research (PPSR) to discuss initiatives from diverse fields and traditions. We describe three predominant models of PPSR and call upon case studies suggesting that—regardless of the research context—project outcomes are influenced by (1) the degree of public participation in the research process and (2) the quality of public participation as negotiated during project design. To illustrate relationships between the quality of participation and outcomes, we offer a framework that considers how scientific and public interests are negotiated for project design toward multiple, integrated goals. We suggest that this framework and models, used in tandem, can support deliberate design of PPSR efforts that will enhance their outcomes for scientific research, individual participants, and social–ecological systems.

Key Words: *citizen science, community-based monitoring, conservation, outcomes, participation, public, volunteer monitoring*

INTRODUCTION

Members of the public are increasingly participating in scientific research and monitoring. Consider the following cases: (a) thousands of birdwatchers across North America collect data that are combined to reveal trends in bird distributions and behaviors, such as advancing first egg dates for nesting tree swallows (*Tachycineta bicolor*) (Dunn and Winkler 1999); (b) residents of Pennsylvania monitor water turbidity, conductivity, and macroinvertebrate populations in tributaries near active natural gas wells to document impacts of gas extraction (Zerbe and Wilderman 2010); and (c) experienced hunters and anglers living near protected areas in the Philippines monitor and react to changes in resource use related to wildlife populations (Danielsen et al. 2007). In each of these cases, lay people interact with scientists to participate in a scientific research effort. Here, in the context of ecological monitoring and research, we explore how certain outcomes may be associated with different approaches to "public participation in scientific research" (hereafter, PPSR).

PPSR efforts have emerged from a variety of social and academic fields, ranging from participatory action research in the fields of development studies (Chambers 1994) and public health (Cashman et al. 2008) to citizen science projects with a long history of ornithology and astronomy research (Droege 2007, Bonney 2008, Raddick et al. 2009) to water quality monitoring (Firehock and West 1995, Ely 2002, Wilderman 2005) and community-based natural resource management (Guijt 2007, Fernandez-Gimenez et al. 2008, Wilmsen et al. 2008b). As collaborative endeavors between science researchers and public participants—including but not limited to amateur experts, concerned community members, scientists trained in other fields, and/or school students—PPSR projects must address the needs and interests of all parties. In this paper, we focus on projects in the contexts of conservation, ecology, and environmental management, where efforts also deal with complex questions and issues regarding how people relate to their environments (Campbell and Vainio-Mattila 2003).

PPSR projects in environmental contexts have successfully addressed complex issues in science and society. Some have collected and mobilized monitoring information to respond to pollution (Overdevest and Mayer 2008), whereas others have improved communication within and across resource management stakeholder groups (Tudor and Dvornich 2001, Lawrence 2006). Projects have increased political participation and social networking around water resource issues (Overdevest et al. 2004) and compiled large data sets to inform landscape management practices for bird conservation (Rosenberg et al. 1999, 2003). To have an impact on conservation, PPSR projects generally strive for outcomes that fall into one or more of three main categories: outcomes for research (e.g., scientific findings); outcomes for individual participants (e.g., acquiring new skills or knowledge); and/or

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outcomes for social–ecological systems (e.g., influencing policies, building community capacity for decision making, taking conservation action).

Such a combination of outcomes has the potential to affect robust and integrated resource management decisions (Pahl-Wostl et al. 2008, Armitage et al. 2009). However, individual PPSR projects do not always consider or acknowledge all three categories of outcomes, which can diminish the ability of a project to address complex problems. Additionally, project activities do not always align well with intended outcomes (Nerbonne and Nelson 2008), and some achieve unanticipated outcomes (Cornwall 2008). Even attentively designed projects require compromises regarding outcomes, such as balancing large-scale data collection against opportunities for close interaction between researchers and community members (Berkes 2004, Evans et al. 2005), or deciding between timeliness and precision in data collection (Whitelaw et al. 2003). Additionally, with information on PPSR outcomes both limited and dispersed across fields, little in the way of empirically based guidance has been available to inform strategic decisions about aligning goals, outcomes, and trade-offs in the design and refinement of projects.

This paper outlines how PPSR project design relates to project outcomes, drawing on work from varied fields of practice. We bring together previously conducted, convergent case studies and synthetic work in conservation management, informal science education, community-based forestry, and volunteer monitoring to describe three predominant programmatic models and their potential outcomes. Our new alignment of models across traditions yields two conclusions, supported by case analyses: (1) the degree to which the public participates in the research process, as well as the quality of that participation, are closely related to the range and types of outcomes achieved; and (2) a common framework can inform project design choices across fields of practice. Therefore, we propose such a framework, based on the quality of participation and the management of interests addressed through a project; present examples to support application of the framework and models across contexts; and explore ways that the framework can be used by project designers in any disciplinary field to deliberately align PPSR project design with specific desired outcomes.

MODELS OF PARTICIPATION

Background

Recognizing the burgeoning of citizen science, in 2008, the National Science Foundation's Center for the Advancement of Informal Science Education (CAISE) sponsored an "Inquiry Group" to help define the field and understand the broad educational impacts of various citizen science models (Bonney et al. 2009a). The group convened practitioners and researchers from diverse fields (all of whom are co-authors on this paper), including volunteer water quality monitoring (Wilderman), participatory action research and community-based forestry (Ballard), science/museum education and public engagement (McCallie), and citizen science related to both ornithology (Bonney, Phillips, and Shirk) and behavioral ecology (Jordan). The group quickly found that confusion over existing terminologies complicated effective communication about different projects.

"Uncertain and contradictory nomenclature" is how Rowe and Frewer (2005) described a similar concern in the broader context of public engagement in science (the context from which this CAISE inquiry emerged). The term "citizen science," for example, is employed in the United States and in the fields of ecology and conservation primarily to describe large-scale data-collection initiatives (Bonney et al. 2009b). In European contexts and in social studies of science, the same term describes a philosophy of engaging public perspectives and knowledges in science discourse and policy making (Irwin 1995). Also problematic is that many initiatives sharing similar programmatic elements employ different terms, such as volunteer biological monitoring (Lawrence 2006); community science (Carr 2004, Wilderman et al. 2004a); community-based monitoring (Danielsen et al. 2009); and participatory monitoring (Bell et al. 2008), all of which we argue can be considered public participation in scientific research.

To acknowledge the tradition of distinct terms on the one hand and the need to share understandings across fields on the other, the CAISE inquiry team proposed the term "Public Participation in Scientific Research" to collectively describe a range of diverse projects. We define PPSR as intentional collaborations in which members of the public engage in the process of research to generate new science-based knowledge. Depending on context, projects may be driven by such goals as public education or the management of social–ecological systems, but in all cases PPSR projects aim explicitly to contribute to scientific research and/or monitoring. PPSR encompasses hypothesis-driven science, such as citizen science investigations into how weather and urbanization constrain the distributions of wintering bird populations (Zuckerberg et al. 2011), as well as projects that employ local knowledge and observational data to address political and social goals for underrepresented communities, such as participatory mapping exercises that aim to bolster local claims of authority over forest territory (Peluso 2005). The use of the term PPSR as an overarching category allows us to explore similarities and differences that are programmatic, as opposed to differences that are primarily nominal or historical. Specifically, we consider different ways in which opportunities are structured for public participation, and how those opportunities relate to the outcomes that projects achieve.

The Context and Construct of Participation

Over the past few decades, academic discussions in the broad contexts of public engagement in science policy, discourse, and research have taken a "participatory turn" (Jasanoff 2003). Much of the theoretical debate regarding participation comes from the fields of development studies (Whyte 1991, Fishkin 2009) and political science (Fischer 2000). In contexts of natural resource monitoring for management, public participation can be a means of engaging diverse stakeholders and accessing new knowledge, making power relationships transparent, adapting activities to evolving conditions, and encouraging both ownership and accountability of the management process among constituents (Kapoor 2001, Armitage et al. 2007, Arora-Jonsson et al. 2008, Wilmsen 2008, Wulfhorst et al. 2008). Such approaches often emphasize generating "knowledge for action" as opposed to just "knowledge for understanding" (Cornwall and Jewkes 1995).

PPSR and other participatory projects can and have achieved some of these potentials. However, simply invoking the language and ideals of participation is insufficient. The term "participation" is used to describe a wide spectrum of approaches for engaging individuals and communities, with each approach often tied to different intentions and outcomes. A recent summary of participation theory by Cornwall (2008) laid out numerous continua of participation in development studies, revealing important distinctions between participation for the sake of garnering "buy-in" and participation that enables social transformation. Although there is now some degree of consensus in development studies regarding appropriate participation strategies (Chambers 2002), Campbell and Vainio-Mattila (2003) and others raise concerns that these hard-won lessons are not being transferred to what we are calling PPSR work. Scholars in both development and PPSR fields call for moving beyond what has become a "rhetoric of participation" (Cooke and Kothari 2001, Cornwall 2008) to identify what Rowe and Frewer (2004) call "effectiveness," the features of an intervention that enable intended outcomes (see also Lawrence 2010a).

Such a move demands the careful, intentional, and transparent employment of participation strategies to achieve targeted outcomes, as well as to help reveal relationships between the way that participatory opportunities are designed and structured and the specific outcomes of resulting initiatives (Cooke and Kothari 2001, Cornwall 2008). Scholars tend to focus on two key facets of participation: degree and quality. In order to inform and support deliberate project design for specific outcomes, whether those outcomes are for individuals, science, or social–ecological systems, it is necessary to identify relationships between both degree and quality of participation and the types of outcomes they influence when handled in different ways.

Degree of participation

Degree of participation is a dimension that can be quantified, compared, and/or standardized. By comparing projects that demonstrate different degrees of participation, we can account for and examine the relationships between participation and various outcomes. Degree of participation can be measured in terms of duration of involvement (Ballard et al. 2008); research effort (Dickinson et al. 2010), numbers (Wilmsen and Krishnaswamy 2008) and/or diversity (Cheng et al. 2008) of participants; the depth/intensity of involvement in the process (Wilmsen and Krishnaswamy 2008); or the power that participants have over the processes in which they engage. Relative degrees of power have in fact been the focal point of landmark typologies of participation in development studies (e.g., Arnstein 1969, Pretty 1995, White 1996), as participation in development and resource management contexts can hinge on power issues and bring about complex political relationships (Charvolin et al. 2007). These typologies, however, conflate power as a degree of participation—how much or how little a given individual/group "may" have—with evaluative statements about how much power a group "should" have (Cornwall 2008). Furthermore, Lawrence (2006) suggests that the normative assumptions of these typologies (e.g., that more power is transformative and less power is exploitative) do not necessarily reflect individuals' experiences in voluntary biological monitoring contexts. In fact, individuals and communities should not be assumed to have an interest in—or be advantaged by—a greater degree of control over a given research process or agenda (Saldivar-Tanaka and Krasny 2004, Cornwall 2008).

For our purposes of relating participation to outcomes of PPSR, we define the degree of participation as the extent to which individuals are involved in the process of scientific research: from asking a research question through analyzing data and disseminating results. We focus on the "process" of scientific research for several reasons. First, as PPSR projects inherently aim to produce knowledge through science, the research process is a common element across all projects. Additionally, the degree of public participation in the research process varies across projects in quantifiable ways—which we illustrate through the models described in this paper—and there appear to be relationships between the degree of participation in the research process and project outcomes. Across the range of ways that degrees of participation are considered in different contexts, scholars agree in a general sense that opportunities for increased degrees of participation can open doors to a wider range of potential outcomes, assuming that the quality of participation is handled thoughtfully (Hickey and Mohan 2004, Wulfhorst et al. 2008).

Quality of participation

Discussions of degree of participation often do not capture important subjective and context-relevant dimensions, such as credibility and trust (Wynne 1992, Wulfhorst et al. 2008), fairness (Rowe and Frewer 2005, Cheng et al. 2008), responsiveness (Gaventa 2004), relevance (Cumming et al. 2008), agency (Cleaver 2004), and due diligence in the development of appropriate research strategies (Cheng et al. 2008). We consider these to be key components of high-quality participation. Many of these dimensions are related to building and negotiating relationships among constituents (Cheng et al. 2008, Wilmsen et al. 2008a). For our purposes of understanding the role of public participation in project design, we use "quality of participation" to describe the extent to which a project's goals and activities align with, respond to, and are relevant to the needs and interests of public participants. This focus on the public is not at the exclusion of the interests of science researchers, but rather reflects work in development studies (e.g., Arnstein 1969, Wilmsen et al. 2008a) to elevate the needs and interests of public participants in contexts where those interests have historically been marginalized. High-quality participation in the design of a project can be found in projects supporting any degree of participation in the research process, so long as the degree of participation adequately reflects the needs and interests of the public.

By paying explicit attention to the social and interactional dimensions that affect the quality of participation, organizers can directly affect the outcomes of a PPSR project. Sustainable and robust outcomes such as environmental management may be most effectively achieved by attentiveness to the issues of whose interests are being served (Kapoor 2001) and how the balance of those interests is negotiated in designing a project and defining desired outcomes (Bell et al. 2008, Wilmsen et al. 2008a). Attentiveness to the quality of participation can also help yield outcomes, such as social learning, that could be considered as critical for retaining participants and affecting conservation (Fernandez-Gimenez et al. 2008, Tabara and Pahl-Wostl 2007, Pahl-Wostl et al. 2008). Luks (1999) and other scholars of post-normal science even suggest that high-quality relationships between scientists and the public can enhance resulting scientific research. The design framework offered in this paper portrays the relationships between scientific and public interests, and between that balance of interests and likely project outcomes, offering a tool for explicitly considering the quality of participation.

We address the degree and the quality of participation as separate but related elements in examining the relationship between participation and outcomes by presenting, respectively, models of PPSR (based on "degree" of participation) and a framework for project development (considering the "quality" of participation). By so doing, we aim to advance thinking about participation in specific, strategic ways in order to inform project design that deliberately considers the outcomes that different degrees and qualities of participation can achieve.

Five Project Models

Our work to create models of PPSR grew out of a need to explore relationships between project design and project outcomes across the many fields of practice in which these activities take place, as well as across the different approaches to project design employed within a given research field. To construct the models presented here, the CAISE team built on earlier typologies of broad approaches to public engagement in science (e.g., Cornwall and Jewkes 1995 (citing Biggs 1989), Rowe and Frewer 2005) as well as of PPSR activities more specifically (e.g., Wilderman et al. 2004a), all of which converge on the degree of participation in the research process as an indicator of outcomes. Several other concurrent explorations of PPSR outcomes, across varied fields of practice and research, have similarly considered the degree of individuals' participation in the research process to be closely related to outcomes (Lawrence 2006, Cooper et al. 2007, Wilderman 2007, Fernandez-Gimenez et al. 2008, Danielsen et al. 2009). The models presented here acknowledge the convergence of thinking by scholars working in different fields of practice and research. Therefore, we look at PPSR projects across fields of practice to explore and elaborate specifically on the different degrees to which the public participates in the process of scientific research.

We divide PPSR projects into five models based on degree of participation:

- *Contractual* projects, where communities ask professional researchers to conduct a specific scientific investigation and report on the results;
- *Contributory* projects, which are generally designed by scientists and for which members of the public primarily contribute data;
- *Collaborative* projects, which are generally designed by scientists and for which members of the public contribute data but also help to refine project design, analyze data, and/or disseminate findings;
- *Co-Created* projects, which are designed by scientists and members of the public working together and for which at least some of the public participants are actively involved in most or all aspects of the research process; and
- *Collegial* contributions, where non-credentialed individuals conduct research independently with varying degrees of expected recognition by institutionalized science and/or professionals.

Table 1 briefly describes the interactions between public participants and scientists in each model, and Table 2 illustrates, for contributory, collaborative, and co-created models, the aspects of the scientific process in which public participants are involved.

Table 1. How public participants interact with scientists through public participation in scientific research (PPSR)

Public action in each PPSR model	Members of the public...
Contract	... ask scientists to conduct a scientific investigation and report on results
Contribute	... are asked by scientists to collect and contribute data and/or samples
Collaborate	... assist scientists in developing a study and collecting and analyzing data for shared research goals
Co-create	... develop a study and work with input from scientists to address a question of interest or an issue of concern
Colleagues	... independently conduct research that advances knowledge in a scientific discipline

The contractual and collegial models lie at the far boundaries of the PPSR spectrum. In the contractual model, which is exemplified by European Science Shops (Jorgensen et al. 2004, Leydesdorff and Ward 2005), the public participates by raising a question of concern, often a question that researchers would otherwise not consider. This model allows an expansion of traditional science research from being driven solely by the interests of researchers (or the needs of the field) to consider community-relevant questions and interests. As opportunities for public participation are limited throughout the remainder of the research process in this model, however, it can arguably reinforce the traditionally distinct roles of scientists as producers of knowledge and the public as consumers, albeit in this case consumers with enhanced control over the research agenda and the resulting knowledge produced.

At the other end of the spectrum is the collegial model, as exemplified by amateur astronomers, archaeologists, and taxonomists, who often work on their own to make important contributions to science (Stebbins 1980, Hopkins and Freckleton 2002). In this model, professional and amateur researchers may collaborate only when an amateur writes and submits findings for peer review and publication. Although often overlooked or highly critiqued, committed amateurs can make critical contributions that may not otherwise transpire owing to a lack of resources, time, skills, or inclinations in the professional scientific community. As such, their work demands a reconsideration of expertise as exclusive to traditionally credentialed scientists (Taylor 1995, Ellis and Waterton 2005). In these cases, the degree of amateur participation in the research process is so extensive and independent that expert amateurs arguably adopt the traditional role of scientist-as-knowledge-producer.

The other three models, which capture a range of public participation in scientific research, align closely with categories recently or concurrently defined by other scholars (Table 3). Although Wilderman et al. (2004b), Lawrence (2006), Danielsen et al. (2009), and others use different terms to label their models, they differentiate models similarly by degrees of practice. Thus, we suggest that meaningful programmatic differences exist not between fields of practice or research, but between project models based on the degree of participation, regardless of the field of practice. Likewise, we suggest that the range of models is very similar across the different fields of practice and research from which PPSR initiatives have emerged and that these similarities are grounds upon which analytic comparisons can be made regarding degree of participation and its relationship to outcomes. For these reasons, we focus the remainder of this paper on the center three models, while acknowledging that programmatic innovation often occurs at boundaries.

COMMON FRAMEWORK FOR DELIBERATE PPSR DESIGN

At the heart of the design process is the quality of participation. The design and implementation of every project requires decisions to be made about whose interests can and should be addressed, and how the end goals, or desired outcomes, are defined. Resulting choices in project design reflect how those interests are considered and negotiated. In some PPSR fields of practice, design choices are guided by theories of participation, expertise, or democracy. In other traditions, project design is guided primarily by a growing body of practical knowledge, along with implicit assumptions about participation or expertise.

We present an overarching PPSR framework to help project developers—whether community members, researchers, or teams involving each—think deliberately about design choices (Fig. 1). This framework, based on the W. K. Kellogg Foundation's (2004) format for outcome-oriented logic models, suggests that negotiations and interactions between scientific interests and public interests can influence a range of potential outcomes. Although the three models (contributory, collaborative, and co-created) can be used to explore implications for projects that employ different degrees of participation, the fundamental question the framework asks is, "whose interests are being served?"

Below, we describe considerations for each of the framework elements (inputs, activities, outputs, outcomes, and impacts), and discuss implications of the ways in which different elements may be treated. Each element, considered alone, represents complex processes worthy of future investigation. For the purposes of this paper, we introduce each with just enough depth to illustrate the framework as a whole. To help demonstrate how different models of participation fit within this framework, we provide brief case examples from a contributory project (Project NestWatch) and a co-created project (Shermans Creek Conservation Association) (each of which is described in more depth in Bonney et al. 2009a).

Table 2. Models for public participation in scientific research (PPSR). X = public included in aspect; (X) = public sometimes involved in aspect

Aspects of scientific research/monitoring process:	Contractual Projects	Contributory Projects:	Collaborative Projects:	Co-Created Projects:	Collegial Projects
Choose or define question (s) for study	X			X	X
Gather information and resources	(X)			X	X
Develop explanations (hypotheses)				X	X
Design data collection methodologies			(X)	X	X
Collect samples and/or record data		X	X	X	X
Analyze samples			X	X	X
Analyze data		(X)	X	X	X
Interpret data and draw conclusions	(X)		(X)	X	X
Disseminate conclusions/ translate results into action	(X)	(X)	(X)	X	X
Discuss results and ask new questions	X			X	X

Inputs

PPSR projects are, by design, collaborative endeavors, and thus project design must manage inputs from multiple constituents. We consider Inputs to be the interests (the hopes, desires, goals, and expectations) of both the public and the scientific community as they come together to determine the focus of a project. Although other interests inevitably come into play (e.g., those of funders, management agencies, political entities), we focus here specifically on interests of professional researchers and public participants as the common elements across all PPSR collaborations.

Public volunteers' interests can include contributing to scientific knowledge (Evans et al. 2005, Raddick et al. 2010), making scientific discoveries (Raddick et al. 2010), collecting and disseminating information on environmental hazards (Overdevest and Mayer 2008), affecting resource stewardship (Wilderman et al. 2004a), protecting livelihoods (Danielsen et al. 2007), or satisfying personal identities and/or learning goals (Weston et al. 2003, McCallie et al. 2009). And, although it is easy to assume that individual scientists are interested primarily in achieving scientific results, some may be just as interested in affecting education (Firehock and West 1995), conservation (Swaisgood and Sheppard 2010), managing their own observational data (Wood et al. 2011), or any of the interests attributed to public volunteers. Interests are also not necessarily homogenous within a group of researchers or a community. Furthermore, the lines between individuals who are "scientists" and those who are of "the public" may be blurred in many cases (Ellis and Waterton 2004).

Nonetheless, the ways that interests are envisioned, articulated, acknowledged, and balanced can be fundamental to the subsequent design steps and, therefore, are likely to influence the outcomes of a project. These interests may in fact be used to define project goals to strive for particular outcomes. We have structured the Inputs category to reflect the interplay of interests between professional science researchers and members of the public considered in the development or enhancement of a research project. Each initiative differently balances these interests (which take into account the motivations, skills, experiences, and available resources of these two groups as well) to identify the focus of the scientific work, which may be a research question, an issue addressed through data collection, or a monitoring protocol.

Cases

Many projects that aim to produce data on a large geographic or temporal scale are contributory in nature, due in part to the necessary spatial distance among participants and project leaders. Often designed almost exclusively by professional scientists, contributory projects address public interests and abilities in part to ensure meaningful participation and data accuracy. For example, projects at the Cornell Lab of Ornithology such as NestWatch take into account the willingness of volunteers to repeatedly monitor bird nests, collect breeding data, and submit their nest records to a central online database, where records can be accessed by scientists and used to detect changes in reproductive timing and fledging success (Phillips and Dickinson 2009). Co-created projects, based extensively on volunteer initiative, may incorporate scientific expertise mainly to ensure that projects are conducted in a scientifically rigorous manner. For example, when residents in Pennsylvania's Shermans Creek watershed wanted to set up a long-term water quality monitoring initiative

Table 3. Key review papers on participation in conservation research and monitoring, comparing models and terminologies. Column headings are terms used in this paper, from Bonney et al. (2009a). Column entries are the terms used in each paper to describe an analogous model, based on the degree of participation in the research process.

	Contributory	Collaborative	Co-created
Wilderman et al. 2004	*Community workers 1*	*Community workers 2*	*Community-based participatory research*
Fernandez-Gimenez et al. 2008	*Community involvement primarily in the data-gathering phase*	*Community involvement primarily in the objective-setting, design, and interpretation phases*	*Community involvement in most or all phases of monitoring*
Cooper et al. 2007	*Citizen science research*	*Adaptive citizen science* and *Adaptive co-management research*	*Participatory action research*
Danielsen et al. 2009	*Externally driven with local data collectors*	*Collaborative monitoring with eternal data interpretation*	*Collaborative monitoring with local data interpretation*
Lawrence 2006	*Consultative* and *Functional* categories[†]	*Collaborative*	*Transformative*

[†]Lawrence applies to PPSR categories and theory derived in context of development studies, but concludes that these particular categories may be presumptuous regarding outcomes in PPSR volunteer biological monitoring contexts.

for the purpose of targeting critical areas for restoration and protection, they enlisted technical input from researchers at the Alliance for Aquatic Resource Monitoring (ALLARM) to help them design and implement a scientifically sound monitoring program (Wilderman 2005).

Activities

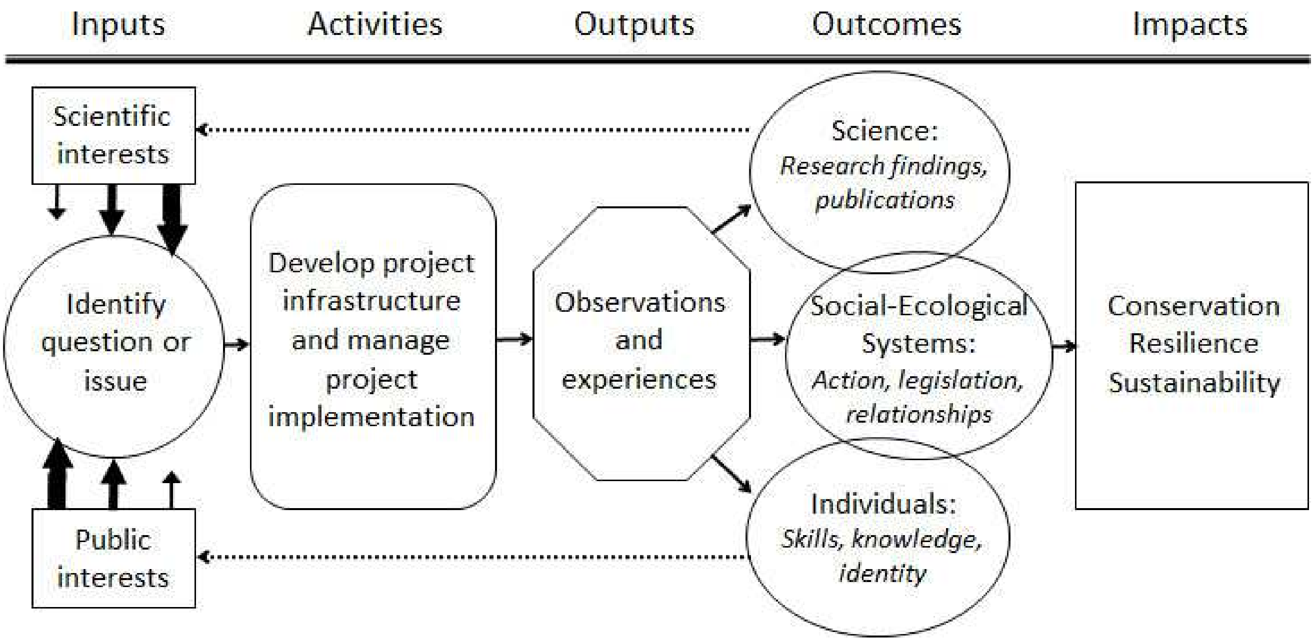
The category of Activities includes the bulk of the work that is necessary to design, establish, and manage all aspects of a project. This work is generally conducted by a lead team, which may include scientists, members of the public, and/or others (educators, technologists, etc.). Importantly, the tasks involved in project design and management differ from the steps of the scientific research process articulated in Table 2, although some tasks, such as protocol development, do overlap. Activities in this context include the tasks necessary for developing project infrastructure, such as designing sampling strategies and protocols, training materials, and data submission/data entry technologies, as well as establishing a network of volunteers and the communication and support mechanisms necessary to maintain their participation. Activities here also include tasks for managing project implementation, such as facilitating training, distributing materials, holding meetings and events, and communicating with all collaborators/participants. Although the focus of this article is not on how to conduct PPSR projects, resources for guiding many of these activities are compiled at http://www.citizenscience.org.

Establishing an infrastructure for data collection and management determines the type and quality of data collected as well as the utility of those data for affecting outcomes (Vaughan et al. 2003, Dickinson et al. 2010). The way that activities are handled will likely reflect how interests have been balanced at the input stage, as the interests represented will influence choices regarding what to measure, how often measurements are taken, and who has control over the resulting data. Engaging scientist partners in these activities can enhance the credibility of data collected (Lathrop and Markowitz 1995, Penrose and Call 1995, Nerbonne and Vondracek 2003). Deep involvement of public participants and communities in these activities can enhance both scientific and local relevance as well as local utility (if not actual use) of findings (Wilderman et al. 2004a, Corburn 2007, Cheng et al. 2008, Nerbonne and Nelson 2008), although actual use of data may require additional design considerations (Nerbonne and Nelson 2008).

Cases

For Project NestWatch, the protocols, data sheets, and a data management infrastructure were iteratively developed by a team of researchers, educators, and technologists, to align with skills of different audiences (Phillips and Dickinson 2009). NestWatch training and support materials (such as a monthly newsletter and video tutorials) are distributed online and by email, and a small staff is available to answer questions by phone. In contrast, members of Shermans Creek Conservation Association (SCCA), after successfully defeating a plan to site a power plant along Shermans Creek, realized that they were going to need baseline data on the condition of the stream in order to participate meaningfully in decisions regarding future development in the watershed. They called upon ALLARM for technical support, and together developed a study design that included the types of data to collect and analyze to provide critical information about the health status of the creek and its tributaries. Project management, including overseeing who was responsible for monitoring and when, was all handled by SCCA membership (Wilderman et al. 2004a).

Fig. 1. Framework for public participation in scientific research projects. Projects must balance inputs from scientific interests and public interests, but each project negotiates that balance differently (as represented by input arrows of different sizes). Projects also exhibit different outcomes for science, individuals (researchers or volunteers), and social–ecological systems, which may relate to the particular balance of inputs. Note feedback arrows: certain outcomes may reinforce certain interests—and therefore particular design emphases—as initiatives evolve over time. Quality public participation depends upon sufficient attention to public interests in the input stage, to identify questions and structure activities most likely to yield outcomes relevant to those interests.



Outputs

Outputs are the initial products or results of activities. Outputs of PPSR collaborations include observations, recorded as data, and the active experiences of making, facilitating, and/or analyzing those observations or measurements. Outputs are often quantified, for example, in terms of the number of observations in a database, or the numbers of individuals, website visits, volunteer hours, workshops, and trainings (Phillips et al. 2012). Differences in project outputs often hinge on how and why data are gathered, how they are used, and the meaning they are given, as well as the depth and meaning of the lived experience (Lawrence 2010b). Outputs will reflect choices (in the activity phase) regarding such things as trade-offs between the depth and precision of data collected and the need for timely responses to environmental conditions (Vaughan et al. 2003), as well as what observations are considered important by different parties (Long Martello 2004, Lawrence 2010a).

Choices of what data are collected, and how those data are made available and usable for different constituents, also heavily influence outcomes, including publications, education, and decision making. Data analysis, workshops for visualizing data, dissemination via community meetings or publications, influence on policy makers, and personal reflection on these experiences all affect the transition from tangible data and experiences to project outcomes. The priority and the resources given to particular interests at the input stage influence the type of observations and experiences that a given collaboration yields and the way any resulting data are used.

Cases

Project NestWatch is designed to gather data on nesting birds across wide geographic and temporal scales in order to understand environmental influences on breeding behavior. This demands the acquisition of an optimal number of nesting records (and thus participants) geographically distributed across species' ranges. In collecting these records, participants experience interactions with birds, their local environment, and the process of making and documenting observations for biologically relevant research. Members of SCCA collected 3 years of water quality monitoring data and then asked ALLARM staff to facilitate a data analysis workshop. The usefulness of this analysis depended not only on the data, which revealed problems in the watershed, but also on the experiences of volunteers working in that watershed to help pinpoint the likely causes of those problems. SCCA members leveraged their subsequent experience in data analysis and interpretation to achieve a number of management outcomes.

Outcomes

Outcomes are measureable elements, such as skills, abilities, and knowledge that result from the specific outputs of a project. Remembering that we are focusing on PPSR in the context of conservation and ecology, we address outcomes of PPSR projects in three categories: those for science, those for individual participants, and those for social–ecological systems.

First, we consider outcomes for science (for a comprehensive treatment of outcomes and associated practices in ecological research, see Dickinson et al. 2010). As just a few examples, PPSR projects have advanced scientific understandings about: trends in species ranges, distributions, abundances, and diversity (e.g., Root et al. 1981, Batalden et al. 2007, Crimmins et al. 2008, Senko et al. 2010); the spread of disease (e.g., Hochachka et al. 2004, Lindsey et al. 2009) and of invasive species (e.g., Cooper et al. 2007, Simpson et al. 2009, Bonter et al. 2010); changes in life-cycle events (e.g., Torti and Dunn 2005, Wolfe et al. 2005), as well as implications of such changes for aspects of human health (e.g., van Vliet et al. 2002, Bigham et al. 2009). Projects have also yielded innovative and enhanced techniques for collecting, analyzing, managing, and networking data (e.g., Baker and Oeschger 2009, Crall et al. 2010, Fink et al. 2010). As one metric of scientific success, Dickinson et al. (2010) estimate that over 1000 peer-reviewed publications and technical reports have been produced using data from just eight large-scale projects. At the crux of outcomes for science is the ability of PPSR to access otherwise unavailable knowledge, whether by compiling large-scale data networks (e.g., Sullivan et al. 2009) or depending on very localized insights (e.g., Berkes et al. 2000). Given this range, it is important to note that the types of scientific outcomes that a project can achieve can depend upon assumptions of project designers about what counts as knowledge and whose knowledge and observations are relevant (Ellis and Waterton 2005, Nerbonne and Nelson 2008, Lawrence 2010b).

Outcomes described for individual participants include development of new skill sets (Bell et al. 2008, Ballard and Belsky 2010), an increased understanding of the process of scientific research (Trumbull et al. 2000, Ballard and Belsky 2010), an improved sense of place and/or stewardship (Wilderman et al. 2004a, Evans et al. 2005), and opportunities to deepen relationships with the natural world (Bell et al. 2008) as well as with other people (Overdevest et al. 2004, Bell et al. 2008, Kountoupes and Oberhauser 2008). Some individuals gain new content knowledge (e.g., Brossard et al. 2005, Evans et al. 2005) or increase their scientific literacy (Trumbull et al. 2000, Jordan et al. 2011). Others gain a sense of ownership of their own knowledge and expertise as it relates to their contributions to science (Bell et al. 2008, Lawrence 2009) and to their surroundings and social contexts (Ross et al. 2008). Professional scientists also experience outcomes as individuals; for example, one study documented that resource agency personnel gained an enhanced understanding of local conditions and an appreciation for the knowledge and skills of undocumented salal harvesters (Ballard and Belsky 2010). Other work suggests that engaging in research partnerships can provide professional scientists welcome relief from their desk jobs (Noss 2001–2002) and even foster a sense of hope in the sometimes-bleak profession of conservation (Swaisgood and Sheppard 2010). Stoking such hopes are outcomes for participants such as enhanced self-efficacy and community capacity, social capital, and agency—in short, the skills and social resources to put knowledge into action (e.g., Overdevest et al. 2004, Jones et al. 2006, Ballard and Belsky 2010).

Outcomes identified for social–ecological systems include improved relationships between communities and management agencies (Tudor and Dvornich 2001, Ballard et al. 2008), backyard enhancement of wildlife habitat (Evans et al. 2005), access to and use of data to address environmental degradation (Overdevest and Mayer 2008), and increased likelihood of participant engagement in policy processes to improve their surroundings (Overdevest et al. 2004, Wilderman et al. 2004a). Resource management strategies can be improved, whether through research findings (e.g., Pattengill-Semmens and Semmens 2003, Rosenberg et al. 2003, Hamel et al. 2009, Campbell and Godfrey 2010), responsiveness to stakeholder knowledge and values (e.g., Bird et al. 2003, Cheng et al. 2008), strategically targeted interventions (Danielsen et al. 2010), monitoring for adaptive management on both public and private lands (e.g., Cooper et al. 2007, Fernandez-Gimenez et al. 2008), or rapid detection of and direct response to environmental problems (e.g., Simpson et al. 2009). Many community-based monitoring and environmental justice projects may in fact start with social–ecological outcomes in mind before deciding that a PPSR approach would be effective to these ends. In adaptive co-management contexts, environmental monitoring in collaboration with stakeholders provides information as feedback on management practices, which can be used to adapt the practices (Armitage et al. 2009). Both enhanced adaptive management practices, and the social learning process that is embedded in collaborative and participatory monitoring, can contribute to more resilient social–ecological systems (Berkes 2009, Walker and Salt 2006). As many of these outcomes hinge on deep collaboration and relationships, this category may be most influenced by the quality of participation at the input stage.

Not all projects yield outcomes in all categories, regardless of goals, and some projects will achieve unanticipated outcomes. Success in achieving one category of outcome may influence outcomes in other categories (e.g., science outcomes improve as participants improve their bird identification skills; management of social–ecological systems may change with new science outcomes and increased public knowledge). We also suggest that as projects evolve, outcomes affect the handling of subsequent inputs. For example, achieving science outcomes likely reinforces science interests. However, sustainable projects likely depend on achieving outcomes in all three categories. In well-designed projects, inputs can be understood as goals, and outcomes should reflect those inputs. Attentive projects can modify their design as interests change or new interests are revealed.

Cases

Successful projects may be weighted toward one outcome category and still be able to achieve outcomes in the other two groups. For example, although Project NestWatch is driven by scientific interests to increase understanding of the factors that limit breeding success, it also emphasizes individual learning outcomes with implications for social–ecological systems, such as increased understanding of breeding biology, increased engagement with the scientific community, improved nest monitoring skills, increased appreciation for the natural world, and increased bird-friendly practices (Phillips and Dickinson 2009). And, whereas SCCA research was originally driven by an interest in collecting scientific data to assess the state of Shermans Creek, efforts resulted in improved relationships between formerly disparate community groups, participation in writing a state-funded rivers conservation plan, a strong educational outreach effort to all municipal officials, emergence of new leadership within the organization, increased scope of activities for the organization, and scientific knowledge skills sufficient to revisit and revise the study design for continuing monitoring efforts (Wilderman 2005).

Impacts

Compared with outcomes, impacts are long-term and sustained changes that support improved human well-being or conservation of natural resources. Whereas short-term outcomes are typically measured within 1–3 years of project implementation and long-term outcomes in 4–6 years, noticeable impacts may only occur only 10 years or more after projects have been established (W.K. Kellogg Foundation 2004). Given this lengthy time scale, impacts are rarely measured. Nonetheless, conservation programs can benefit from distinguishing impacts from outcomes to address the interests of stakeholders operating on different time scales, such as land managers and funding agencies (Bottrill et al. 2011).

Desired impacts may include sustained stewardship and conservation (Penrose and Call 1995, Pattengill-Semmens and Semmens 2003), a knowledgeable and empowered citizenry (Middleton 2001), resilient human and natural communities (Fernandez-Gimenez et al. 2008), and responsive science (Penrose and Call 1995). Because of the integrated nature of such impacts, they may best be achieved through combined successful outcomes for research, individual participants, and social–ecological systems (Ballard and Belsky 2010). Because impacts are difficult to measure and confirm, in the remainder of this paper, we focus our attentions on project outcomes.

RELATING INPUTS TO OUTCOMES OF DIFFERENT MODELS

To gauge the usefulness of the framework and models for guiding project design, we turn to several recent syntheses and comparative analyses of case studies. In Table 4, we follow Danielsen et al. (2009) and document—for contributory, collaborative, and co-created projects—the outcomes described through empirical syntheses and case studies. We also consider available information on the costs and benefits of different approaches. From these cases, we can see that outcomes do tend to relate to the degree to which members of the public are engaged in the research process. Similarly, projects do demonstrate outcomes that align with predominant inputs.

These cases suggest that each model has strengths and limitations in terms of expected outcomes. In general, contributory projects are associated with robust scientific research outcomes and content knowledge gains, whereas co-created projects have demonstrated success in affecting timely policy decisions and enhanced resource management capacity of communities (Wilderman and Shirk 2010). These cases also reveal trade-offs regarding the resources and capacity needed to achieve outcomes of interest. For example, although co-created projects are driven and organized to a large degree by communities, they may actually involve as much if not more input, resources, and commitment by scientists than would a contributory project.

We assert, however, that the particular outcomes documented in these synthesis papers are likely more attributable to design choices regarding the quality of participation (whose interests are being served), than they are to the degree of participation. Concluding their programmatic synthesis, Fernandez-Gimenez et al. (2008) note that, "... clear objectives and design, rather than the type or phase of community participation, seem to determine the level of ecological learning," and we suggest that this is likely true across all three categories of outcomes. For example, developers of a project such as the co-created SCCA water quality monitoring initiative that prioritizes community interests in timely, locally relevant, actionable data may not be concerned with designing their study to yield the kind of precise and generalizable data that are often important for peer-reviewed publication in scientific journals. It is important to distinguish this as a result related to inputs, rather than to the degree of participation itself; involving participants more deeply in the research process does not inherently result in data that are less scientifically interesting

Table 4. Relationships between public participation in research models and observed outcomes from five synthesis studies (Wilderman et al. 2004, Lawrence 2006, Fernandez-Gimenez et al. 2008, Danielsen et al. 2009, Bonney et al. 2009a)

	PPSR model, by degree of participation		
	Contributory	Collaborative	Co-created
Outcomes for:			
Individuals	Low potential for enhancing stakeholder capacities*; increased content knowledge and science inquiry skills§; participant appreciation of complexity of ecosystems and ecosystem monitoring‡; indications of changes in attitudes across constituent groups‡; increased technical monitoring skills‡.	Some potential for enhancing stakeholder capacities*; individuals develop intimate knowledge of place and strong sense of stewardship|; participant appreciation of complexity of ecosystems and ecosystem monitoring‡; indications of changes in attitudes across constituent groups‡; increased technical monitoring skills‡; increased participant confidence§; increased knowledge of science concepts and processes§; increased awareness of environmental issues§; increased appreciation of data collection concerns§.	High potential for enhancing stakeholder capacities*; individual capacity to develop protocols, interpret data, and present results|; strong sense of community, commitment|; strong understanding of meaning of data|; meaningful participation in advocacy and decision making|; participant appreciation of complexity of ecosystems and ecosystem monitoring‡; indications of changes in attitudes across constituent groups‡; increased technical monitoring skills‡; increased science content knowledge§; increased science process skills, particularly for refining questions and interpreting data.
Science	In developing countries, acknowledgement that local knowledge can be necessary for accessing data*; data precision and accuracy high*; high capacity to inform large-scale monitoring schemes*.	In developing countries, acknowledgement that local knowledge can be necessary for accessing data*; data precision and accuracy high*; high capacity to inform large-scale monitoring schemes*; presentations at professional conferences|; efficient data collection at large scale|.	Intermediate expectations of data precision and accuracy*; intermediate capacity to inform large-scale monitoring schemes*; laboratory experience for students|.
Social–ecological systems	Decision-making slow to result*; increased understanding of the impact of management practices‡; fostered shared understanding of ecosystem assessments‡; some degree of increased trust among stakeholders‡; informal communication of monitoring results to community members‡; formal communication of monitoring results to partner agencies‡; some stewardship action and behavior change§.	Decision-making slow to result*; citizens used data to testify at state-level hearings|; agencies used data to revise management practices|; participant gains in knowledge of community structure, environmental regulation, and management strategies§; agency acknowledgement of participant knowledge and credibility§; increased understanding of the impact of management practices‡; fostered shared understanding of ecosystem assessments‡; increased trust among stakeholders‡; formal and informal communication of monitoring results to community‡; increased social capital§.	High potential for prompt decision-making*; outcomes including conservation easements, best management practices, and restoration projects|; funding secured for community initiatives|; increased capacity of university program to partner with community organizations|; participant gains in knowledge of community structure, environmental regulation, and management strategies§; increased understanding of the impact of management practices‡; fostered shared understanding of ecosystem assessments‡; increased trust among stakeholders‡; formal and informal communication of monitoring results to community‡.
Costs to:			
Individuals/ communities	Intermediate*	Intermediate*; resource intensive†;	High*; responsible for volunteer recruitment and retention|; requires commitment to intensive consensus building process for goal setting|; responsible for planning for action outcomes during design phase, and implementing plan|

(con'd)

Researchers	Intermediate*	Intermediate*; resource intensive†; responsible for volunteer recruitment and retention, data analysis, interpretation, and dissemination|; limited technical training and support necessary|	High to establish, low to maintain*; responsible for intensive support of community goal setting|; provide intensive technical training and support|; development of support strategies for community data analysis|
Compromises	Data quality can decline if volunteers become complacent after repetitive tasks†; projects designed primarily by agencies or researchers have fewer opportunities for building trust, community, and social outcomes across stakeholder groups‡	May need to choose between precision and reliability, between data collection for scientific validity and data collection for education and empowerment†	Likely a slower process|; outcomes more aligned with social change than with scientific precision|; projects designed primarily by citizens have fewer opportunities for building trust, community, and social outcomes across stakeholder groups‡

* Danielsen et al. (2009). Synthesis of robust outcomes data. Context: natural resource monitoring.
† Lawrence (2006). Case studies. Context: voluntary biological monitoring.
‡ Fernandez-Gimenez et al. (2008). Case studies. Context: community-based forestry.
§ Bonney et al. (2009a). Case studies, focused on informal science education outcomes. Context: public participation in scientific research.
| Wilderman et al. (2004). Observed outcomes across projects. Context: volunteer water quality monitoring.

or useful. Likewise, engaging thousands of people across large geographic scales does not itself preclude the development of community building efforts or the applicability of data to locally relevant concerns; although building community for a large project may be challenging and certainly requires innovation, it can conceivably be done.

Projects must, therefore, reflect carefully on, and design deliberately for, the interests that sustain participation and yield the full range of desired outcomes for both science and the public in each specific programmatic context. It is worth considering what advantages could be gained by applying lessons from one model to another, particularly with regard to deeper participation by the public. Using the framework and models in tandem, project leaders can choose to enhance outcomes beyond what a particular model might be expected to yield, through (1) consideration of the challenges and opportunities of different models (e.g., Danielsen et al. 2010) and (2) enhanced attentiveness to the interests of the public in participation opportunities and desired outcomes (e.g., Fernandez-Gimenez et al. 2008).

CONSIDERATIONS FOR USING THE MODELS AND FRAMEWORK

Deliberate project design—that is, thoughtfully employing a design strategy that will yield specific and measurable project outcomes—requires project designers to begin with the end in mind. The complexity of conservation-oriented PPSR projects stems from the need to keep multiple ends in mind, considering that achieving significant gains for conservation may likely depend upon affecting related outcomes for science, individual participants, and social–ecological systems. Deliberate project design benefits from understanding the range of interests that need to be addressed, to inform clearly articulated goals (Nerbonne and Nelson 2008, Powell and Colin 2008, Alliance for Aquatic Resource Monitoring 2010).

There are often tensions between interests (Nerbonne and Nelson 2008), and design requires certain compromises among and between project developers and other constituents. As Bradbury and Reason (2008) suggest, "The degree of participation ... must be negotiated among co-researchers in every participatory research project." Although certain degrees of participation may efficiently achieve particular outcomes (e.g., contributory projects generally result in large-scale data sets), projects should consider both whether a given degree of participation is sufficient to achieve desired outcomes, and if it is within the capacity of all partners to participate or facilitate. New projects have the opportunity to consider whether a hybridized model might address a broader range of outcomes. Likewise, as ongoing projects reflect on their accomplishments and opportunities to address goals in new ways, they may strategically add new, complementary participation activities that more deliberately address specific outcomes.

Bradbury and Reason (2008) also suggest that, "...the quality of participation must be evaluated on an ongoing basis." Not all interests may be known or recognized at the outset of a project, and new interests may arise as a project evolves. Given that projects need not be locked in to a certain model, project designers and managers who are attentive to changing, or newly revealed, interests can strategically adapt participation approaches.

Projects can also facilitate different degrees of participation by different individuals. In fact, it is likely that individual participants create their own unique experiences, regardless of a project's predominant model of participation (Lawrence 2006). In co-created projects, it is not uncommon for a core group of individuals to be deeply involved in the entire process of research while others participate in discrete activities such as data collection or analysis (e.g., Farquhar and Wing 2008). Some contributory projects also intentionally facilitate opportunities for individuals or groups to conduct their own research investigations (Tomasek 2006).

No matter how individualized a participant's experience may be, the social and interactional aspects and outcomes of PPSR participation should not be underestimated. In fact, unintended social outcomes may come to be seen as essential precursors to achieving goals, because increased opportunities for social interactions may sometimes be necessary to sustain or deepen project participation, build relationships for sharing knowledge (e.g., Cohen 2010), and even enhance resulting science or management actions (e.g., Plummer et al. 2007). If designing for the fullest range of potential outcomes, the social aspects of participation should be considered for all partners.

In general, typologies of participation and project design are best considered tools for understanding trends, as practice inevitably "blurs boundaries" (Cornwall 2008). Additionally, every PPSR initiative arises in a unique context, in response to different needs, meaning prescribed approaches are unreasonable (Wiggins and Crowston 2010). In fact, practitioners and theorists in development fields suggest that generalized participation methodologies can result in dogmatic practice, diverting attention away from quality participation, the essential element of building the foundations for trust, credibility, and reciprocity, and other factors critical for achieving desired outcomes (Wilmsen and Krishnaswamy 2008). For this reason, we see the participation models and associated work offered here as descriptive starting points that highlight relationships between inputs and outcomes. We encourage project designers to use these guidelines creatively to address needs specific to their context, and to reflect and report on the results in order to inform the growth of this field.

CONCLUSION

Across fields of research and practice, collaborations involving public participation in scientific research share the common element of explicitly engaging the public in the research process to produce science-based knowledge. Although scientific research is at the heart of these initiatives, we see the PPSR movement as much more than just the gathering of data for science or management. It is precisely the inherent mix of likely outcomes (for science, for individual participants, and for social–ecological systems) that makes PPSR a powerful concept, particularly in fields of conservation and natural resource management where actions must respond to integrated social–ecological needs with diverse understandings and knowledges. Given that any one PPSR project will invariably have some effect on outcomes across all three categories, there is all the more reason to design deliberately so that activities align with, and therefore affect, intended outcomes for sustainability, resilience, and conservation.

The process of studying and understanding the best ways to develop, implement, and evaluate PPSR is just beginning, bridging a number of different social and academic traditions from which these initiatives have emerged. Given the convergence of findings thus far, there are advantages to continued conversations and investigations that span these different fields of research and practice. Research about PPSR is also being conducted in fields not explicitly discussed here; for example, in public health research (e.g., Cashman et al. 2008, Minkler and Wallerstein 2008), astronomy (e.g., Raddick et al. 2009), traditional ecological knowledge (e.g., Berkes 2004), mediated model building (van den Belt 2004, Cockerill et al. 2007), and information sciences (e.g., Wiggins and Crowston 2011). Further collaborative work can help us all broaden and refine definitions and, more importantly, practice. We believe that the field of PPSR will grow in new and compelling directions if project developers and PPSR scholars (of whom there are a growing number) begin a critical analysis of program design using the presented framework as a guide, learning from history in certain fields of practice and innovation in others.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/vol17/iss2/art29/responses/

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CHAPTER 3

"SOMETHING ELSE NEEDED TO HAPPEN." SCIENTIFIC EXPERTS AND THE CONSERVATION POSSIBILITIES OF CITIZEN SCIENCE

ABSTRACT

Given the gulf between conservation research and conservation action, scientists are increasingly expected (by peers and the public) to attend to social as well as scientific aspects of complex ecological problems. However, different institutional, disciplinary, and cultural expectations that intend to safeguard technical knowledge production may limit the socially-minded aims that individual scientists see as possible and appropriate to consider. In the context of citizen science, where scientists have the opportunity to address intersecting social and scientific interests, I explore the conservation targets individual scientists describe as possible to influence and the pathways by which they presume citizen science can affect those targets. I share narratives of practice that reveal a rich set of possibilities that are motivating scientists' work with citizen science. The pathways they articulate, based on their experiences, acknowledge the complex and often social nature of conservation problems. Together, these suggest that scientists may be seeing citizen science as an opportunity to address socially complex conservation objectives not instead of their science, but through their science. These narratives can help us expand our consideration of scientists' aims and interests, and our appreciation for how experts might pursue both research and socially-minded conservation action.

INTRODUCTION

What possibilities and pathways are open to scientists who want to influence conservation? The following sentiment, shared by sea turtle biologist Wallace "J." Nichols of the California Academy of Sciences, may resonate with many ecologists:

> *... the idea that you collect data and then use that data to manage a species at risk, or an ecosystem at risk, makes sense. But ... I was realizing that that's certainly not enough. And not just not enough, but the connection between the science and conservation action is pretty weak. Something else needed to happen.*

For researchers doing their best to bring their science to bear on problems of concern, the situation that J. describes can be quite discouraging (Chapin et al. 2011; Palmer 2012). One pathway that has received some mention as a possible means of influencing conservation in new ways is citizen science (Bickford et al. 2012, Whitmer et al. 2010, Ehrenfeld 2009). I define citizen science as intentional collaborations between scientists and members of the public, which generate new science-based knowledge for research or management (Shirk et al. 2012; Chapter 2). Such partnerships may involve scientists soliciting data from observers around the globe in order to understand large-scale population trends, or they may focus more on local collaborations to research species or ecosystems at risk. Whatever the configuration, citizen science partnerships can affect outcomes for science, for education, and potentially also for more complex social-ecological goals such as conservation (Dickinson and Bonney 2012, Shirk et al. 2012).

In Chapter 2, I propose a model that suggests that the interests and intentions of scientists can be influential in the design – and therefore in the potential impact – of citizen science projects (Shirk et al. 2012). Such goals are best achieved when projects are designed intentionally with those outcomes in mind (Jordan et al. 2012, Shirk et al. 2012; Chapter 2), but little is known about scientists' desired outcomes or the thinking that guides their work towards those outcomes. It is easy to presume (and easy to mis-interpret the model in Chapter 2 as suggesting) that scientists would be driven primarily by scientific interests in outcomes such as data and publications. While some scientists may face institutional or cultural resistance to discussing or pursuing socially-minded outcomes beyond collecting and using data, the presumption that technical knowledge production is their only interest seems a one-dimensional view of scientists both as individuals and collectively, and also insufficient to account for their investment in such an unconventional and risky practice.

From my experience with citizen science, I understand the scientists involved to be deeply concerned with and attentive to technical scientific aims. I also suspect that their intentions and motivations are more complex and nuanced than a simple interest in data and publications. I propose that in conservation contexts they may be seeing new possible pathways for moving from data to conservation action.

Building on outcomes-oriented methods of conservation evaluation (Margoluis et al. 2009), I explore the narratives of nine prominent scientists with sustained commitments to citizen science in order to broaden understandings about how experts think about and approach complex social-scientific problems. Specifically, I ask:

> Q1. What kinds of conservation outcomes do individual scientists see or discover, through their experiences, as possible to achieve and

appropriate to pursue through citizen science? What aims or purposes inform and guide their citizen science work?

Q2. How do these individuals describe the pathways by which citizen science might facilitate those outcomes? What practical theories inform the outcomes and pathways they articulate?

Insights from this research allow us to think critically and expansively about the ways scientists see relationships between technical science and civic-minded purposes such as conservation. Drawing on scholarship around professional work and expertise (Sullivan 1995, Schön 1983), I consider the meaning of scientists who discuss socially-minded conservation outcomes as within the purview of their own work, as opposed to the responsibilities of other players in the conservation landscape. This inquiry has implications for the roles and work in which scientists might engage, which I address in Chapter 4. Here, I explore a more fundamental aspect – the possibilities and purposes that motivate individual scientists to pursue and sustain difficult citizen science work, and the experiences and theories that guide their choices in those pursuits.

PRACTICE AND PURPOSE: THE CONSERVATION SCIENCE CONUNDRUM

The discipline of conservation biology was born as a "mission-driven" science, grounded in the premise that conservation science can and should influence conservation action (Soulé 1987, Meine et al. 2006). But securing effective pathways between research and action continues to be both a challenge and a major point of discussion in the field (e.g., Lauber et al. 2011, Knight et al. 2006, Meine et al. 2006). Many of these discussions emphasize the need for scientists to provide rigorous evidence to inform decisions, while simultaneously recognizing that the pathway to conservation is not that simple. To effectively address the research-action gap, we need a better and more nuanced understanding of the connections scientists see between their work and the conservation outcomes they aim to affect, as well as a richer set of possibilities for addressing complex problems.

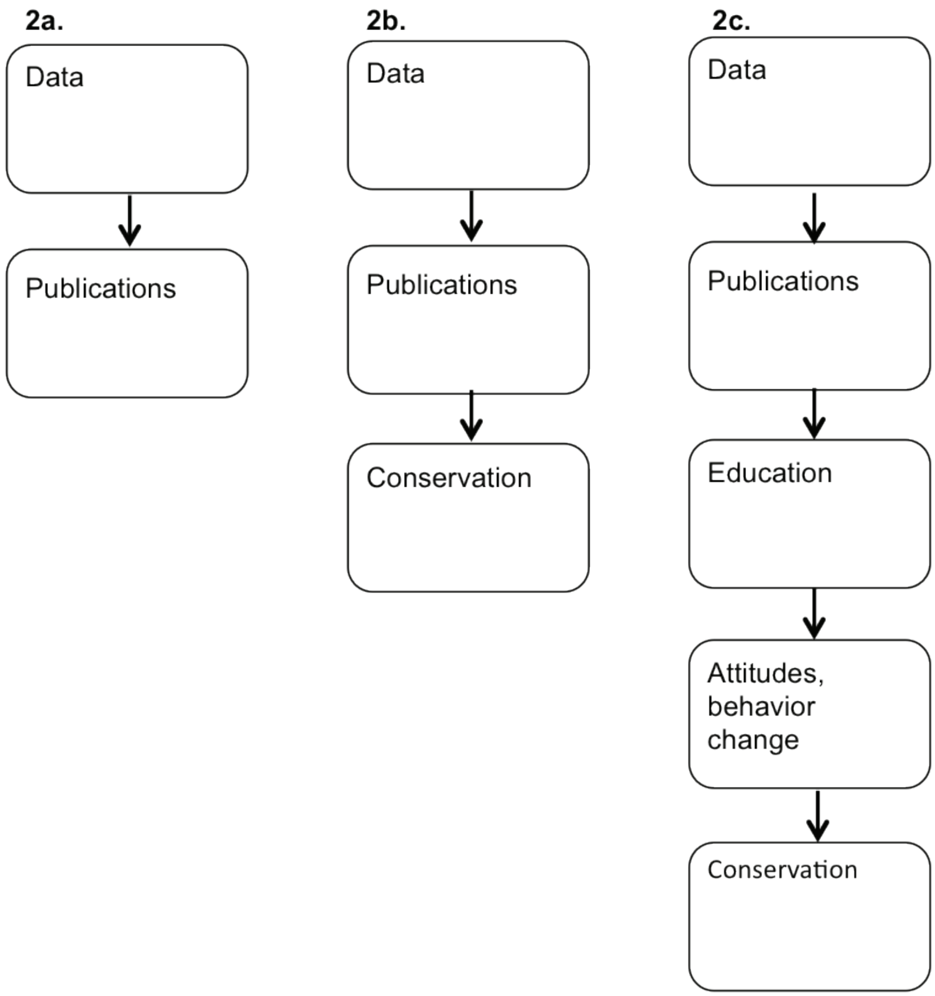
Naming, let alone pursuing, outcomes that fall outside the realm of technical research may often be considered as in conflict with or detracting from rigorous science, as historically norms of scientific research have been framed to protect experts from outside influences and responsibilities (Sullivan 1995). While specific institutional and disciplinary cultures vary, the legacy of a 20th century emphasis on technical efficiency still serves, in many cases, to maintain boundaries between the process of knowledge production and the social values or implications of the research (Sullivan 1995, Wing 2003). Traditions can thus tend to weigh heavily against scientists considering or pursuing pathways to conservation that aren't easily recognized by reward structures, such as public engagement (Poliakoff and Webb 2007). They can also tend to privilege outcomes that may not align with the timeliness, scale of relevance, or decisiveness needed for conservation action (Vaughan et al., Steel et al. 2004).

The discipline of conservation arose in the 1980s well aware of these constraints, and leading ecologists have called out the need to challenge traditions (Meine et al. 2005, Palmer et al. 2005). There are contemporary calls to seek and acknowledge alternative pathways to conservation that engage social considerations (Palmer 2012, Chapin et al. 2011). Many individual scientists are undoubtedly engaged in such pursuits, but even though such work may these days no longer be discouraged, in many institutional settings it may still be underappreciated and therefore go unrecognized.

Citizen science is one venue where we might gain some insights. Scientists working with these projects invariably encounter others' perceptions that their involvement with the public is in conflict with the project of knowledge production. I suspect that scientists may have interests in citizen science as mean to affect conservation action related to their research, but the pathways to action through citizen science are poorly understood. Two broad presumptions about how citizen science might influence conservation include: a) that action will be informed by the scientific knowledge produced, and b) that when public participants gain knowledge they will subsequently adopt positive conservation behaviors (Figure 2b-c). Both of these presumed pathways to conservation action are rooted in a technical approach towards conservation. The former reflects a practical theory that technical knowledge can and should influence conservation action, the feasibility of which has been called into question by the opening quotation of this chapter (see also Chapin et al. 2011; Palmer 2012). The latter reflects a practical theory that getting more information to more people will be sufficient to influence knowledge, attitudes, and behaviors to affect conservation change, a pathway that conservation psychologists are quick to point out is far too simplistic (e.g., Schultz 2011).

I suspect scientists are seeing and pursuing much more nuanced pathways towards conservation through their experiences with citizen science. I propose that the need for "something else" to bridge the research-action gap in conservation (e.g., Robinson 2006, Laurence et al. 2012) may call for and even depend upon broadening the scope of possibilities considered as appropriate for scientists towards both scientific research

Figure 2 (a-c). Presumed practical theories and pathways towards conservation outcomes. These reflect simplistic assumptions, which we aim to expand, regarding: a) scientists' interests in citizen science; b) and c) scientists' interest in citizen science in conservation contexts.



and purposeful action to address complex social-scientific issues. Through this research, I consider how the experiences and insights of scientists engaged in citizen science can help us see opportunities to pursue conservation outcomes with both technical and social dimensions, within careers that have traditionally drawn sharp boundaries around technical knowledge production.

RESEARCH APPROACH

This research is driven by a need to explore the possibilities offered by citizen science. My intention is not to make predictions or test theories about scientists' interests, but rather to reveal and bring attention to the possibilities scientists are seeing in citizen science, particularly for outcomes that they may not be able to pursue through other means. The questions at hand, which aim to capture perceptions of practice (Q1) and the implicit thinking that guides everyday choices (Q2), cannot easily be addressed by surveys, observations, or even typical approaches to interviewing. The nature of knowledge necessary to understand purposes, possibilities, and practical theories is such that it is embedded in experience and in practice (Ospina and Dodge 2005, Clandinin and Connelly 2000, Schön 1983). As described by Schön (1983), "the know-how is *in* the action," (emphasis in the original). Such knowledge can be tacit, and thus often unvoiced (Ospina and Dodge 2005). Guided by an interest in understanding and informing practice, a growing number of fields have lately turned to narrative research as a rich source of insight into the work of professionals (Chase 2011).

Narrative research is an effective means of eliciting individuals' purposes and intentions (Peters 2010), and revealing the improvisation and judgment that practitioners employ when engaging in complex work (Forester 1999.). Narratives allow us to describe things that we may not directly see, but imagine are possible (e.g., Palmer 2012). We all use narratives to process our actions, and to explain or justify (to ourselves and others) our sometimes-difficult choices (Chase 1995, Moore et al. 2005). The process of sharing narratives can also provide scientists with a rare opportunity to reflect on, make sense out of, and articulate otherwise tacit and implicit assumptions and theories that guide their work (Peters et al. 2010, Ospina and Dodge 2005*,* Rae 2004).

In other words, narratives can, at times, serve as hypotheses. Narratives unfold as proposed relationships between events and outcomes, from which we can begin to sketch the pathways that scientists presume will influence conservation. Through scientists' narratives of practice, we can recognize their practical theories (narratives that suggest, "I do this because...") about how they as professionals can and should engage the public for conservation. Practically, they can also reveal pathways for other practitioners to consider what might work in their own practice (Forester 1999). With an interest in learning from and informing practice as well as scholarship in the fields of conservation and citizen science, we turn to narrative research.

Narrative research

This inquiry was part of a larger research effort to explore why and how scientists are making citizen science a part of their careers in conservation research or management. I conducted in-depth interviews with nine scientists who demonstrated commitments to citizen science initiatives (Appendix A). I sought scientists with PhDs in conservation-related fields, who demonstrated sustained involvement (5 years or more) in ongoing and/or successive citizen science initiatives. Together, these criteria suggest professional investment in – and dependence upon the success of – the research aspects of their citizen science work.

Individuals interviewed represented diverse professional settings, including management agencies, research universities, and non-profit research institutions. I focused on individuals working in four research domains, recognizing great diversity across the work of each individual within these domains: bird research, sea turtle research, water quality research, and butterfly research. Within each domain, I chose individuals whose work spoke to different approaches to public participation (per Chapter 2, Shirk et al. 2012).

A semi-structured script (Appendix B) invited narrative accounts of scientists' work and choices. Rather than pursuing specific answers to specific questions, the interview protocol was to invite rich stories that can reveal implicit as well as explicit understandings of meaning, experience, and change. Interviews with each scientist cumulatively lasted up to three hours, spanning several phone calls over the period of 2009-2012. Calls were recorded and transcribed. A practitioner profile was constructed for each interviewee by editing together discrete conversations, removing the interviewer's voice and any redundant passages, to result in a cohesive first-person narrative (Forester et al. 2005). All narratives were iteratively reviewed by each interviewee, before completion, for faithfulness in representation of events and meaning (Chase 1995, Forester et al. 2005, Peters 2010). Full practitioner profiles are available in Appendix C.

Interpreting narratives

I address the interpretation of narratives in two stages in this chapter. In the section entitled Findings, I provide narrative excerpts and visual models, per methods described below, which speak to each research question. I draw attention to what can be seen in these details that is significant, compelling or insightful, and provide a brief summary of findings at the end of that section. In the section entitled, "Discussion," I consider how these findings help expand conceptual conversations, both about the possibilities available to scientists pursuing complex social-ecological interests and about the nature of civic-minded professionalism more generally.

Q1, Purposes

'Conservation' is an imprecise and complex term for the task of naming and assessing outcomes of any form of scientific research. Conservation evaluation – which has a goal of revealing and advancing effective conservation strategies – depends upon articulating specific conservation 'targets' as the desired outcomes of a particular initiative (Margoluis et al. 2009). While interviews did not specifically ask scientists to name conservation targets, the resulting narratives revealed many different targets each scientist articulated as meaningful and possible outcomes of their citizen science, and within his or her purview.

What constitutes a target can be fluid. A targeted outcome named by one individual may be described by another (or even the same individual in a different point in time) as an interim step towards a different conservation target. I relied on the narrative context to reveal targets that an individual speaks of as being synonymous with, and sufficient in fulfilling their commitments towards, conservation – recognizing that individuals have different understandings of what they can and should be doing towards these ends. Targets identified in the profiles are listed in Table 1, and are categorized using the three categories of outcomes from Shirk et al. (2012): outcomes for science (S), for individual participants (I), or for more integrated social-ecological systems (SES).

Q2, Pathways

To effectively achieve conservation targets, Margoluis et al. call for making explicit any assumptions about how activities might influence outcomes (see also Weiss 1995). Such assumptions, also called 'theories of change,' may be informed by academic research, but more often than not are based upon *practical theories*. Practical theories are, "… complex constellations of beliefs that have a powerful and constraining impact on ... practice" (Gess-Newsome et al. 2003). Practical theories reveal assumptions about what works, as well as perceptions of what is appropriate and possible (Peters 2010).

These theories, when articulated in sufficient detail, can also reveal pathways by which scientists presume that their work will affect particular outcomes. Margoluis et al. depict such pathways graphically as 'results chains,' illustrating, "... the hypothesized relationship among actions and desired impacts." Results chains portray presumed relationships between strategies employed, desired outcomes, and the impact of those outcomes on conservation targets (Foundations of Success 2007).

I identified instances in the narratives where scientists articulated theories of change in regards to conservation targets (per Peters 2010, see also Rae 2004). Interviews did not solicit theories of change explicitly, as such abstract concepts can be difficult to reliably name and convey. Rather, I reviewed narratives for instances of scientists interpreting their own work, offering practical theories as to why they made particular choices, or revealing the experiences and understandings that underlie the outcomes they presume to be possible. A selection of practical theories is presented as both narrative excerpts and, for some theories with sufficient detail, as results chains (following Foundations of Success 2007); hereafter I refer to these as "pathways."

Addressing validity

One validity concern of narrative research is the relationship between, as Polkinghorne (2007) puts it, "... people's experienced meaning and the narratives they tell about this meaning." The selection of targets and pathways that I highlight here is neither exhaustive nor exclusive – individuals certainly have desired outcomes and practical theories that were not revealed during our conversations. What is important for our purposes is not whether these scientists' practical theories or pathways are accurate depictions of what actually happens. What is important is that they hold significance for the individuals sharing them as being possible, potentially feasible, and appropriate means of pursuing conservation targets within their professional careers, such that these individuals find them meaningful enough to inform their choices in ongoing citizen science work.

A second aspect of validity to be attentive to regarding narrative is, "... the connections between storied texts and the interpretations of those texts" (Polkinghorne 2007). To avoid over-interpreting the theories and relationships conveyed through narratives I present very basic and linear results chains, which illustrate how an individual theorizes the pathway between project activities and a given conservation target (Figures 3-5). Future and ongoing work with individuals could invite reflection specifically on more detailed relationships between actions and outcomes, and would be an important step for an inquiry focused on program design and evaluation.

FINDINGS

Q1, Possibilities and purposes

Scientists named targets of interest related to conservation that align with expectations of technical experts, such as compiling data, conducting monitoring, and identifying factors related to population change. But, scientists also named many conservation targets for their citizen science work that generally are not considered within the purview of professional scientists. These include outcomes for individual participants, ranging from science literacy to dignity and pride. These also include many nuanced and complex targets such as conflict resolution, protecting pristine places, and reframing how we think about science in relationship to society. Conservation targets are presented in Table 1.

In this table, I call attention to two specific details. First, there is a collective diversity of targets named across the nine interviewees. This invites consideration of how context and experience may influence the outcomes seen as possible, or considered to be meaningful, by individual scientists.

Second, each individual articulates a diversity of targets that includes both social and scientific outcomes, as well as targets that imply complex social-ecological interactions. While it can be acceptable for scientists to be driven by socially-minded goals for future work, red flags can be raised in some institutional and social contexts when scientists suggest that they are deeply involved in the pursuit of action in parallel with their pursuit of research. Given this, it is notable that these individuals are finding it not just significant but *possible* to name such a wide range of targets that their work might affect. Recognizing this

Table 1. A selection of conservation-related targets articulated by scientists interviewed in this study. These targets are offered by each individual as possible, plausible, and meaningful outcomes of their citizen science work. Targeted outcomes are listed using language as close as possible to that conveyed in interviews, simplified in cases only for space. Targets are coded as representative of an outcome for science (S; research findings, publications), for individuals (I; skills, knowledge, identity), or for social-ecological systems (SES; action, legislation, relationships), per Shirk et al. (2012).

Dan Canfield	
Data as an insurance policy to call upon if something goes wrong	S, SES
Data demonstrating trends and patterns across lakes and over time	S, SES
Identify problems	SES
Lake management	SES
Stakeholder decision making based on science	SES, I
Productively engaging situations of conflict	SES
Solve/resolve problems	SES
Caren Cooper	
Participants increasing connections with birds, nature, and science	I
Identify vulnerable species	SES
Participants seeing their yards in more of an ecological frame	I
Data showing trends	S
Understand people to inform management of complex systems	SES
Getting people to act in a coordinated way for a positive, cumulative impact on the environment	SES, I
Integrating science with decision making	SES
Reframing an understanding of science as serving society	SES
Matthew Godfrey	
Inform Federal level endangered species management plans	SES
Inform permitting processes	SES
Inform species recovery plans and criteria for assessing recovery	SES
Determine how management actions affect sea turtle sex ratios	S
Beachfront owners and observers caring for the beach and the turtles (e.g., cleaning beaches)	SES, I
Public actively improving species management	SES, I
Informing and influencing better management techniques	SES
Forming a coordinated network of individuals working together for sea turtle conservation	SES, I
Litigation against a state agency to change bycatch practices	SES
Ensuring management actions are based on biological and ecological science	SES
Bill McShea	
Landowners enacting grassland restoration practices	SES, I
Practical advice to managers that takes multiple variables into account	SES
Landscape scale monitoring	S

J. Nichols	
Basic research on endangered sea turtles, in order to begin working to protect them	S, SES
Building a network, a team to care and advocate for turtles	SES
Acquiring new and/or necessary knowledge	S
Communicating and sharing knowledge	SES
Building camaraderie by tracking sea turtles together	I
Community-based endangered species monitoring and research in Marine Protected Areas	SES
Informed stewardship by local people	SES, I
Solving problems	SES
Turtle populations recovering	SES
Participant science literacy	I
Dignity, community, pride	I
Communities supplementing/supplanting agencies to implement conservation actions	SES, I
Communities using knowledge for action or change	SES, I

Karen Oberhauser	
Identify factors and mechanisms related to population variability of monarchs	S
Parents wanting their kids involved in conservation or environmental action	I
Demonstrating trends in monarch populations	S
Volunteers taking direct conservation actions	SES, I
Volunteers advocating politically for conservation ends	SES, I
Volunteers interacting with others and teaching conservation	SES, I

Julia Parrish	
Data to demonstrate population patterns and trends	S
Recognize impact of untoward events	S
Participants gaining information to figure out what is going on in their local environment	SES, I
Resource management	SES
Volunteers gaining a more responsible voice in conservation issues, backed by a whole dataset	SES, I
Network of diverse data streams about beaches	S
Communities talking about issues using data	SES, I
Science becoming more proactive and adaptive by opening the process to the public	SES

Terry Root	
Working on real-world problems	SES
Doing applied research on issues such as climate change	S
Voters vote people in that understand that climate change is a big issue	I
More people supporting work to address the issue of climate change	SES

Candie Wilderman	
Catching "acidic episodes" in Pennsylvania streams	S
Groups taking direct action to address concerns related to water quality	SES, I
Data to be able to tell if something is going wrong in a watershed	S, SES
Watershed group writing a rivers conservation plan	SES
Individuals calling a legislator	SES, I
Participants develop a sense of stewardship, to love a place and be motivated to care for it	I
Database to document the impact of acid rain in Pennsylvania	S, SES
Data used in problem solving	SES
Fixing problems	SES
Protect pristine areas in watersheds	SES
Change land use and zoning regulations	SES
Upgrade streams	SES

prompts questions as to how scientists might reconcile interests that scientific norms would suggest are in conflict. We can gain some insight into potential reconciliation through the practical theories and pathways to action articulated by scientists.

Q2, Practical theories and pathways

Narratives revealed practical theories about the pathways by which individual scientists presumed their work could engage and influence targets for social-ecological systems. While each of the nine interviewees articulated distinct theories and pathways, I focus here on the practical theories and pathways offered by just three individual scientists. These three help us see and appreciate the widest range of possibilities for pursuing both social and scientific aspects of conservation. One is a practical theory that sounds simple at first glance: the need to "get information out" to the public. The associated pathway reveals Terry Root's presumptions about the particular ways citizen science might enable not just public knowledge but public political action. I consider Bill McShea's practical theory that, "you gotta work with landowners," in order to affect restoration practices, and how his pathway to this outcome positions volunteer monitors as influential. And I pick up on J. Nichols' claim that "something else needed to happen," to review his theory that, "people use this knowledge themselves," – knowledge he describes that local people helped to produce and can therefore meaningfully employ to steward their environment and their livelihoods.

These findings are presented through excerpts from each scientist's narrative, as well as in results chains that describe pathways using additional details from each respective narrative (Figures 3-5). I note here again that the questions at hand consider the possibilities scientists articulate, based on their experiences, that are sufficiently meaningful as to motivate their engagement in this difficult work. For my questions, what is important is what they see as possible and not what is actually being achieved. These practical theories and pathways lay the groundwork for future investigations to explore the efficacy of these possibilities.

"Get information out"

Terry Root is one of the pioneers of citizen science, beginning her work using Christmas Bird Count (CBC) data as a Master's student in the 1980s. She is clear about having pragmatic interests in citizen science for research:

> *I am an ecologist that looks at the world on a very broad scale. In order to do that you have to use other peoples' data, and finding other peoples' data that are scattered around a continent and in enough locations that you can actually draw conclusions is impossible unless you use citizen science. Basically I wouldn't be where I am now, at all, if there wasn't citizen science.*

Here it is important to reflect on the context in which Terry has approached citizen science. Her work with the Christmas Bird Count is such that she is not at all responsible for, or beholden to, the work of engaging the public in this project. She easily could access and interpret the data without any consideration of the public connection to it beyond requisite data quality concerns. And yet the interests and purposes she discusses are not limited to data for research. Terry recognized the linkage between Christmas Bird Count data and the issue of climate change, and saw an opportunity to address what she calls, "real world problems." Speaking more broadly than citizen science, Terry expresses a general theory that:

> *... if you're working on real world problems you need to get the information out to the public. We can all be sitting in our Ivory Towers and doing as much applied science as we want, but it's not going to change the world unless you get it out to the public. And it's very important to have the public understand, which often means you are having to condense, abbreviate, use metaphors and the like, which can make your colleagues uncomfortable and even upset. But when I got on the scene, making science accessible to non-scientists was no longer seen as a negative, but it was certainly not seen as a positive. I think it was more of a neutral situation. But it could easily end up being "careericide" because if you say something, if you simplify it so much that it loses its oompf, your colleagues can get very upset with you...*

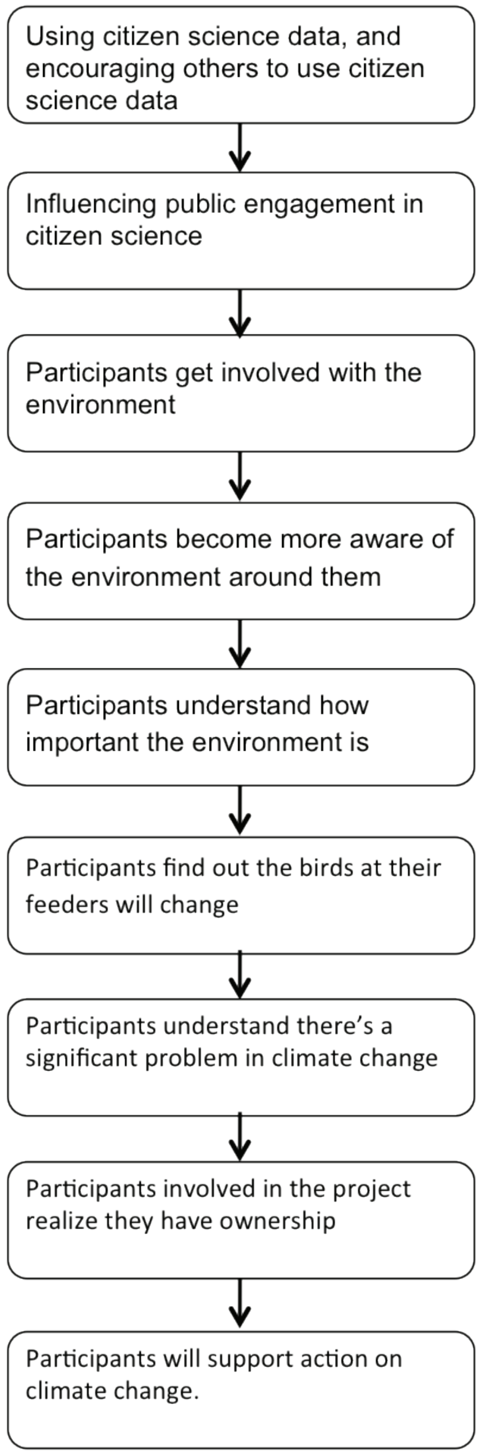
In this excerpt, we can hear Terry countering the simplistic presumption that scientific knowledge is sufficient to affect change (Figure 2b). But we then hear her articulate a theory that may not sound much different than a simple pathway of creating and disseminating knowledge for action (Figure 2c). It is important to note her acknowledgment that pursuing even this simple pathway to change was challenging for scientists in her academic setting.

However, Terry goes on to describe a practical theory specific to citizen science and its potential to influence not just public understanding but also public action on an issue important to her:

> *... I see citizen science as being a way to get people involved with the environment and understanding how important the environment is. One of the ways that people take ownership of something is by being part of it. We need the public to understand that there's a significant problem in climate change, and the more people we can get working on aspects of nature, the better. That way they have ownership, and as the globe warms, for example, they'll realize that could damage things they value, leading them to support necessary changes.*

I call attention to Terry's use of the phrase, "get people involved," and of the word "ownership." Her practical theory suggests that the act of being an observer, and being a part of the process of creating knowledge, may be what facilitates public appreciation of the environment and ultimately public action to support it. Such assumptions can be heard as well in the growing literature related to citizen science, education, and conservation. It invites important questions, currently being investigated by education scholars and evaluators, about whether involvement in the research process has a key role to play in influencing awareness and understanding, let alone action (Jordan et al. 2012). This is particularly called into question given the length of the pathway articulated by Terry, with each step representing an assumption about an outcome that may or may not hold. While perhaps a bit idealistic, this is not entirely a naïve

Figure 3. Pathway to climate change action as understood from the practice narrative of Terry Root.



perspective on Terry's part, as she shares that she herself grew up participating in Christmas Bird Counts with her family.

It is particularly worth calling attention to Terry's expressed interest in influencing participants to, "support necessary changes" on the issue of climate change. Elsewhere in her narrative, she explicitly notes that, "to do that, you have to have people vote." With social norms that generally portray scientists as detached from public interests, and institutional cultures that can serve to discourage public action, it can be unexpected to hear a scientist express clear political objectives. Climate change is one arena where many scientists have found the preponderance of evidence to compel action. Given this, and given that Terry' work with CBC involves primarily data analysis, citizen science may be less professionally risky than other issue-focused activities that Terry shares she engaged in to these ends, including interdisciplinary research and providing testimony to Congress.

And yet, Terry is not entirely a passive player when it comes to enacting the pathway to change that she articulates. She shares, "the primary way that I have worked towards influencing public engagement and education is by encouraging students to not be hesitant to use data that have been collected by citizens." This encouragement extends beyond students:

> *I think Christmas Bird Count data were one of the catalysts that changed folks to start looking at a large, very large scale. When I did my work, and when it all came out in '88, I was one of a very small handful of people that were looking at ecological processes at a large scale. Very, very few of us were doing it. And I think that as my work came out, and the work of other people who were working at that scale, when their*

work started coming out, everybody got excited about it. And it really did make a difference I think. I think having data that were collected on a continent-wide scale, which by necessity means that it has to be collected by professionals and non-professionals alike, that were used to uncover important ecological and physiological findings, showed the absolute necessity of citizen science. I helped to show that the data were indeed...., basically, I was able to use the data and find very important ecological findings and physiological findings and people then were more satisfied that that was something that was, that could be done. That the data were indeed usable, they weren't just crummy data. So I think that by doing my research at a large scale and showing and doing things in a robust manner, it got other scientists to realize that they could use other's people data, too, and do the same type of thing.

Terry's involvement in early work to demonstrate the usefulness of citizen science data for science (see, for example, Bock and Root 1981) has helped provide a scientific foundation on which thousands of citizen science projects today now stand. More work must be done to determine the ways in which public participation in research may itself influence public understanding and action. But by seeing, pursuing, demonstrating, and promoting the possibilities citizen science offers for scientific research, a case could be made that Terry's scientific work and influence has potentially served a multiplier effect, offering a foothold of scientific usefulness upon which citizen science has since expanded into multiple disciplines employing diverse engagement approaches.

"You gotta work with landowners"

Similar to Terry, Bill McShea expresses very practical interests in citizen science:

> *I am a wildlife ecologist with a strong bent toward conservation or applied management. ... And usually I'm looking at such a broad landscape that I can not do it all myself, and I need to have a lot more hands out there and citizen scientists are a good alternative to trying to support four technicians....*

However, unlike Terry who has few opportunities to encounter observers directly, Bill works directly and intensively with volunteers. He is up front about the tensions this can raise at points, in terms of balancing his need for landscape-scale data and the expectations for his professional productivity:

> *I think it ebbs and flows, that you are a scientist, you are supposed to be producing publications, you are supposed to be bringing in grants, and a lot of these things don't end up heading toward the big grants and you should drop them and do the things that have the products. But there is, there is, especially within the Smithsonian, the whole, you know, "increase and diffuse knowledge to men." We have to diffuse this knowledge out there. And especially within the federal government, I am one scientist, I can only stand one place in any time, I cannot do everything that has to be done. So, if I can recruit these people into the system, it's a multiplier effect that I can, I can be surveying the Appalachian Trail and collecting butterflies at the same time [laugh]. ... if the federal government would turn around tomorrow and say, well here's technicians for you, I'd say "ok, well now there's a lot I can do." But it's not going to happen, it's not going to happen any time soon. So the increasing, diffusing part is going to have to involve volunteers.*

Hearing just this, we might again assume that Bill's interests and pathways to conservation align with the notion of creating and disseminating knowledge, very explicitly expressed here by Bill in the words of the Smithsonian's mission statement. It is significant enough to note that he has professional interests to "diffuse" knowledge in addition to "increasing" it through research, and that he sees citizen science as a means to doing both. And yet there are more complex interests and pathways that we can see from additional work Bill describes. Among the numerous citizen science initiatives with which he has been engaged, one involves sending volunteers to research butterfly diversity on large tracts of private farmland in northern Virginia. In the state, these are the only remaining parcels of grasslands. He remarks, therefore, that:

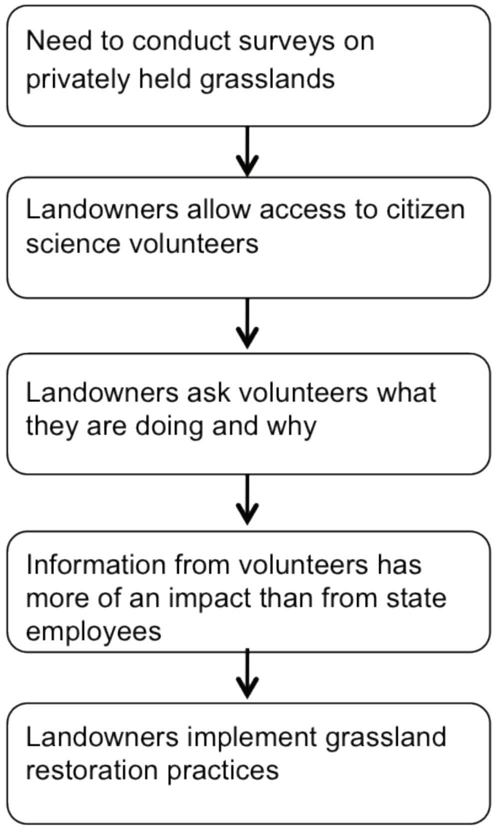
> *...if you really want to do conservation on that ecosystem [grasslands] you gotta be working with private landowners. And they're antsy about government people, and official workers and ... they seem to be much more receptive to citizens, to the general public, to the birding club. They ... seem to like that better than the government's going to send a team of people onto your land to see what you've got. So it seems to work best.*
>
> *... and the landowners, you know, here are these volunteers coming on their land ... and they see them out there all day, and they say "what are you doing, and why are you doing it?" And that seems to have a lot more power to them than, "here are four state employees coming on my land."*

We can understand Bill's intentions here to be for a certain kind of change, as he very explicitly states, "we're trying to talk landowners into doing grassland restorations on their land." His work to influence conservation in this way may thus be instrumental, to a certain degree. But he sees this work for grassland restoration as also having value for the landowners. Noting that these are largely wealthy landowners, and that, "most of them have, an affinity to what we're doing," his approach is to have volunteers conduct biodiversity inventories, "to give them snapshots of how their land is doing." Additionally, he remarks:

> *We have a lot of landowners talking to other landowners, saying "hey, what are you doing over there? Ooh, I want to do the same thing." Whereas if I came to them and said "I want you to save these grassland birds, they would say "well, you know, give me a tax break for that." ... And I think the state realizes that, the state has quail plan things where they can give money to landowners who adopt certain management practices that are conducive to having quail. But most of these landowners don't know about it, or are not interested in taking direction from the state. But when they find out their neighbor just did something, then they ask their neighbor "how did you pay for it?" and they say "oh, this state guy gave me this money." Then they're interested in it.*

Bill's pathway (Figure 4) conveys an understanding that scientific research alone is not going to inform a change in management practices on grasslands, and even that the dissemination of scientific information is not likely to have an impact given mistrust of agency personnel. This pathway reveals an acknowledgement of the social factors at play, the complicated and even compromised role of science and scientists in influencing that process, and Bill's willingness to engage that complexity through citizen science to influence the outcomes he sees as important. The pathway to conservation that Bill describes here positions citizen science not just as a means of pursuing research but also as a means of navigating or facilitating relationships with and between people, towards conservation. He expresses that such opportunities to influence conservation action, "makes citizen science worth it."

Figure 4. Pathway to grassland restoration as understood from the practice narrative of Bill McShea.



Seeing Bill's suggestion that the purpose of his citizen science might be in part to facilitate restoration practices can lead us to reconsider theories about scientists as passive or detached players in the conservation landscape. Whereas Terry's theory describes change agents from whom she is far removed, Bill is in contact with the individual landowners whose practices he is interested in influencing. His pathway speaks to an interest for conservation to be enacted not just in light of evidence, but also in light of the social dynamics he has come to understand through these partnerships.

"People use this knowledge themselves"

J. Nichols' reflection that, "something else needed to happen" to affect conservation was informed by many years of engaging a network of local communities – including fishermen who harvested sea turtles – in turtle research and in sharing their knowledge about turtle populations. When he started this work, he was conducting research into some very fundamental scientific questions regarding the critically endangered black sea turtle:

> *We were really just asking basic questions. So, what's there? And the basic demographics, characterizing the population – how many males? How many females? Where are they, what are their growth rates, where do they come from? ... What do the turtles eat, what are they doing on their feeding grounds, what's the home range?*
>
> *We needed to know a lot about what was going on – basic stuff, characterizing who-what-where-when – to know what we were dealing with. Sometimes it seems like the conservation agenda is used to justify research that may or may not be essential. In this case there was some really essential basic research that needed to be done, and the argument that it needed to be done was really solid, because very little was known. Didn't know where the black turtles were coming from, needed to know that in order to begin to try to help them.*

Here, even though J. is talking about "basic research," it is couched from the very beginning in regards to an interest to "help" the turtles. Research was a necessary component of that. But J. (and his colleague Jeff Seminoff, with whom he worked) was approaching that research as a PhD student, and he shares that faculty members strongly advised against tackling this subject for a very practical reason:

> *If you want to ask an important ecological or evolutionary question, you need some animals. If you don't have animals, then you can't get your degree. This was a pretty experienced group of people giving their best advice to a couple of young scientists, and I think they had all been through something of the sort before, in terms of students or colleagues trying to study animals that were disappearing, and so they were sharing their advice and understandably suggesting that this might not be the best choice of thesis subject. And then we didn't take their advice.*

J. saw an unconventional possibility for enabling this difficult research: working with turtle hunters to find turtles and collect data. J. theorized that, "... working with people who'd spent their lives on the water – not only on the water but catching turtles, because that's what people did – it seemed like the best way to go." This was at a time when turtle hunting had just been outlawed throughout Mexico. J. therefore found himself working closely with a group of people who had been implicated, by the government, in the decline of the very species he was trying to save.

This early work with turtle hunters grew into connections with many coastal communities and turtle researchers, and ultimately into connections between all those groups through an entity named *Grupo Tortuguero*.

> *One of the outcomes of* Grupo Tortuguero*, is to create this monitoring project. And it turns out most of the sites are in some sort of Marine Protected Area. So now you've got community-based endangered species monitoring and research within MPAs, and when some of the official people looked up and saw what was going on, they said, "whoa, that's an amazing thing. That's what we talk about, but haven't been able to implement." In theory, there's a lot of discussion of community-*

> *based or participatory work to do within Marine Protected Areas, or protected areas in general, and that's a goal. And here it's been going on for over a decade, and kind of happened without a lot of fanfare, and without a lot of funding, just by being kind of thoughtful and practical, and really looking for smart, efficient, and so much – common sense. But if you step back from it all and you kind of go, "how should this go?" This makes the most sense. People who care about and live in a place take on – make a living at, or involved in, studying and stewarding and protecting these animals. Makes sense.*

Here we can hear J. acknowledge the value of informing theory with insights from practice, particularly in regards to participatory and community-based research. The deeper details of J.'s narrative can begin provide practical insight into practice that, as J. notes, has largely been discussed at the level of theory. Elsewhere in his narrative he shares that he himself sought practical insights into theorized practices around such research approaches, through direct engagement with other researchers doing such work (e.g., Felger and Felger 1985). We can hear in the following excerpt that J.'s efforts to facilitate the development of the *Grupo Tortuguero* network were also informed by practical theories, in this case theories informed by what he understood to *not* be working, as much as what he understood to be possible. His comments below reference an approach to conservation work that he helped develop, called the Conservation Mosaic, which involves networking, knowledge, and communication (see Nichols 2006):

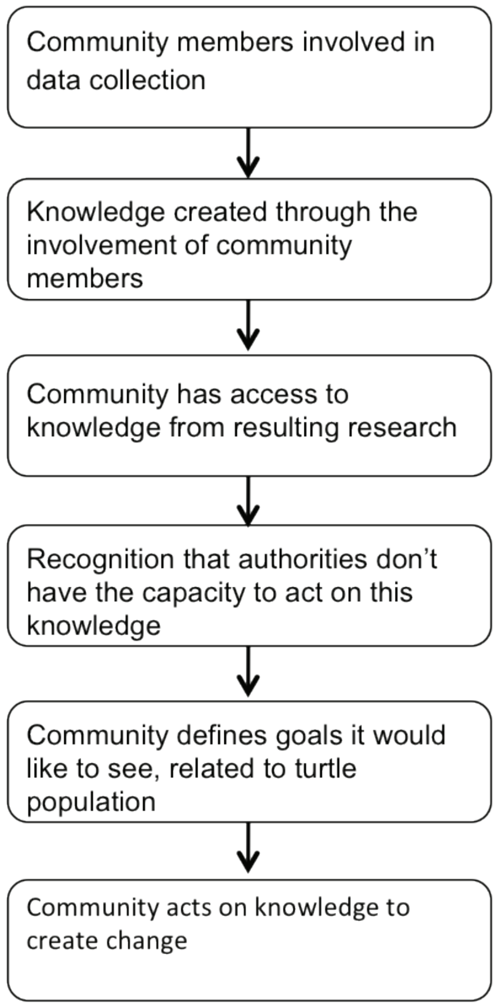
> *You can't just create the knowledge and hand it off and just expect action from the authorities, because they [the authorities] just don't have the capacity to do that. And so that network – knowledge – communication approach involves the authorities, to the extent that they are able to participate, but doesn't depend on them. And that's*

> *really clear when you take a step back from it and look at the body of knowledge that's been generated over the past twenty years, the role that citizens have played in that, but then also the "what's next" part of it, which goes back to the very people who created the knowledge. Not just fishermen and community members, but also the researchers, the NGO leaders, the funders, local businesses who may have supported the project in some way, so that the capacity of that group of people to create protection for sea turtles, that is really where the power is, and not in the offices of La Paz, or in Mexico City. If we keep expecting them to take the reports and the data and turn it into action – it's kind of a ridiculous dream at the moment, and it's been a bit of a dream all along. I think it's pretty clear to people that the way it's going to work is for people to use this knowledge themselves and create movement from it, or action or change or whatever it is they're after.*

The pathway that J. shares here – that communities use knowledge to create change (Figure 5) – does not challenge scientific knowledge as important for informing action, but it does redraw the traditional and anticipated pathway that presumes conservation action will be informed by research conducted by scientists. J.'s pathway both starts and ends with the local communities, rather than the "authorities," or agency personnel, formally responsible for research and management.

This is another unexpected pathway; one that J. may uniquely have more leeway than many scientists to pursue. In his words, he, "... decided to shed the concept of having to work for one entity, and to rethink a career, in terms of working with lots of different organizations and agencies and academic departments." Even if J. may be in a position to be less challenged by cultural or institutional norms in articulating and pursuing such targets, this pathway can still invite questions about ways to effectively enable public interests driving the scientific

Figure 5. Pathway to community-based conservation action as understood from the practice narrative of J. Nichols.



agenda. This pathway speaks to a broader interest by some conservation scientists in opportunities for technical knowledge production to be informed by social considerations (e.g., Palmer et a. 2005). But such a pathway can also raise concerns about undue influence in the conservation process, either on the part of the public or on the part of scientists (e.g., Cooke and Kothari 2001). Regardless, in these excerpts J. is showing us that he does not see public interests as being in opposition with technical knowledge, but rather that they may be essential for both its production and effective use for sea turtle conservation, even when that conservation is enacted by the public.

Summary of key findings

The narrative excerpts and conservation targets shared here bring to light a wide range of ways of thinking about how, through citizen science, these individual scientists see and recognize opportunities for "something else," that they can do to bridge the research-conservation gap. These help us to see the theoretical "bets" people are making that guide their choices to take up and support citizen science in certain ways, and towards particular outcomes. Through the targeted conservation outcomes named, and the practical theories articulated towards achieving them, we can start to see a more complex and nuanced picture of the possibilities citizen science can offer scientists, in different settings, to pursue both scientific and social aspects of conservation beyond the presumed (or afforded) normative pathway of data-to-action.

These scientists do have, and convey, a strong interest in the research outcomes of citizen science. But, by naming targeted outcomes that include community-based monitoring or landowners restoring habitat, they show us that their commitments to conservation aren't restricted to the production of data and publications. These narratives offer a contrast to what we might expect of experts based on traditions that isolate tasks of knowledge production and knowledge use. These individuals do not talk about socially-minded outcomes as in conflict with technical outcomes such as data, but rather as congruent with, complemented by, and in some cases even enabled by them. While important future work will involve revisiting what may be idealized views of complementary social and scientific interests, I call this out here as significant as a meaningful and motivating element of the work of these individuals in citizen science.

Furthermore, the pathways that these scientists articulate regarding those targets suggest that they are seeing socially-oriented outcomes to be within their scope of influence. They show us scientists who are looking beyond the assumption that science alone is sufficient to affect conservation. These individual scientists are showing us their understanding of conservation as a socially embedded process, and science as just one piece of that puzzle. Their narratives suggest that these individuals recognize other pathways offered by citizen science, ones that provide opportunities for engaging nuanced and complex social dimensions that come into play in working towards conservation objectives. They suggest more complex interactions between the processes of knowledge production and the enactment of conservation change.

DISCUSSION

Practical considerations

These targets and theories show us an expanded range of what may be possible for scientists, but they don't necessarily indicate whether any of these outcomes are *probable*. Some of the potential conservation targets, and pathways to those targets, are more convincing than others as to how likely they are to play out in the ways envisioned by these individuals. Drawing out these theories and targets does, however, give us a starting point for moving from possible practice towards probable outcomes. Narratives can be used as tools to enhance both planning and evaluation. They are a productive way of helping professionals articulate goals and pathways, and a means uncovering any problematic assumptions (Rae 2004, Gess-Newsome et al. 2003). By reflecting on the feasibility of outcomes and the reality of the practical theories presumed to affect them, I suggest that scientists can begin to adapt practices to more intentionally pursue conservation targets. Articulating these pathways can also help attribute work and outcomes to scientists who may not otherwise receive – or even think to take – credit for their efforts (Weiss 1995).

But in these narratives we can also recognize that it may be difficult at times for scientists working in certain settings to explicitly discuss interests in certain kinds of conservation targets or pathways. This may be due to cultural and institutional norms, as Terry describes regarding the potential "career-icide" of public communication work, or social norms such as Bill experienced with landowners' wariness about scientists' intentions. Desired outcomes and practical theories inform the choices that scientists make, whether these things are spoken or – more often than not – unspoken. Given institutional traditions and expectations, it can be difficult for scientists to imagine different strategies for bringing their science to bear on such complex circumstances. These expectations can strongly influence what scientists see as appropriate and possible practices. They can also shape what the public presumes scientists will bring to the table (Fischer 2000, Palmer et al. 2005 citing Cash). For scientists to be intentional and effective at influencing complex conservation outcomes, it may require a more permissive space to discuss and engage socially-minded interests within the context of science.

As a step towards that, these narratives begin to show us a side of scientists who are aware of, and willing to engage, both the social and the technical aspects of complex problems. They reveal possibilities for how scientists can transcend traditions and larger narratives that, a) portray scientists as distant, disinterested, or exploitative, and b) can constrain scientists to working in isolation from the problems they are interested in solving. While opportunities will always vary depending upon particular settings and experiences, the insights from these individuals across different contexts offer promising possibilities for the reconciliation of technical knowledge production and the pursuit of public interests.

Theoretical considerations

Seeing these possibilities can help open up larger questions about the relationships between social and scientific interests in regards to complex problems, and the ways experts in scientific professions might re-envision traditional pathways to change. William Sullivan, in a critical history of professional work (1995), considers the relationship between technical expertise and civic-minded work. He points to an early 20th-century trend towards specialized, technical work, which put institutional structures in place to support and attribute expert authority on the basis of efficiency and standards of practice. Such traditions and norms were established to enhance the competencies and efficiencies of technical experts. While this could be described as clinical detachment, Sullivan suggests that this was understood as necessary to safeguard the production of expert knowledge to address known, specialized needs of society.

Today, however, there is a greater recognition of practical uncertainties, social complexities, and the changing nature of both the problems and the systems in which those problems need to be addressed. The scientists whose narratives we heard from here are working in domains of contentious and intractable problems – climate change, habitat loss, and species extinction. Many of these and other similarly complex social-technical domains, often described as "wicked problems," (e.g., Berkes 2004) can be confronted by what has been described as a, "... skeptical reassessment of the professions' actual contribution to society's well-being through the delivery of competent services based on specialized knowledge" (Schön 1986, p. 13).

In the face of such skepticism of public relevance, Sullivan (2003) asserts that professionals, including scientists and other academics, must, "... deploy technical expertise and judgment not only skillfully but also for public-regarding ends and in a public-regarding way." He calls the enactment of these attributes "civic professionalism" (see also Sullivan 1995), making a case that the future of the professions depends upon integrity in serving the interests of the public. This is a provocative claim, one that raises important questions about how different scientists perceive the interests of the public, as well as the means by which they pursue such interests.

I confront these questions specifically in regards to conservation, a field in which some scientific experts are themselves exercising skepticism in regards to the impact of their own contributions. David Ehrenfeld, for one, acknowledges that, "... all of our technologies of prediction and control... may not be sufficient to bring about the desired results of conservation without massive support from events and processes that have little to do with our professional expertise" (2000). Other leading ecologists and conservation biologists are proposing ideas that challenge traditional research-to-action pathways, such as Earth Stewardship (Chapin et al. 2011), actionable science (Palmer 2012), and community based conservation (Berkes 2004). Countering the sometimes-narrow expectations of experts, these explicitly call for scientists to engage more openly with social dimensions of conservation in addition to their technical work.

Such ideas and ideals offer important challenges and visions for integrating public and scientific interests, but leave open understandings about how such visions might be fulfilled in practice. I suggest that citizen science offers a case in which to identify and address both promises and problems that arise when individual scientists pursue work at the intersection of technical and public interests. The narrative excerpts shared here can also begin to help us better understand how the theoretical concept of civic professionalism, for example, may play out in practice. Peters et al. (2008) bring attention to ways civic professionalism plays out in the work of scientists in higher education and the land-grant system. They suggest that we may underestimate the significance that scientists find in work that surpasses technical ends and technical means, to address more socially minded goals.

For example, we can hear in Terry Root's narrative just how meaningful it is to her to be able to address the issue of climate change. She makes a judgment call that it is worth the risk of "career-icide" to "get information out" to the public. She and Bill McShea each express clear interests in specific actions informed by their science – respectively, public voting on climate change, and landowners restoring grassland ecosystems. Terry's public-regarding ways to that end involve encouraging public participation in the process of observation and technical knowledge production through citizen science, so that, "... they'll realize that [climate change] could damage things they value." Bill's public-regarding ways to the end of grassland restoration entail his awareness of social processes and social influence, to convey through non-threatening channels what could be mutually-beneficial opportunities (financial support for restoration action).

J. Nichols expresses a clear interest in sea turtle conservation, but his pathway expresses an interest, "... for people to use this knowledge themselves and create movement from it, or action or change or whatever it is they're after." This reflects a judgment call on J.'s part, likely based on experience more than supposition, that community interests coupled with community-driven data collection will result in stewarding marine resources, including turtles.

These are all promising possibilities for engaging both the social and the technical aspects of conservation. But it can be troubling to hear some of these interests expressed. We are not socially accustomed to science or scientists with a purpose. And yet we see social and even political aims being voiced here by individuals in scientific careers. These insights challenge presumptions about the process of knowledge production, which has often been considered to be necessarily isolated from outside interests. Concerns about data quality can't be overlooked – the integrity of knowledge production, sufficient for the purposes at hand, can't be called into question if citizen science is to effectively address the technical as well as the social aspects of complex problems. Concerns about participation and power, particularly about exploitation of volunteers (e.g., Cooke and Kothari 2001), can also be raised, particularly in the many situations where scientists and technical knowledge are privileged.

One disciplinary practice that manages a similar tension between reliance on technical expertise and the need for socially minded action on complex problems is medicine (e.g., Ehrenfeld 2000). Some conservation leaders point to medicine as an exemplar of effective evidence-based practice (Pullin and Knight 2001). Others recognize that conservation action is often required in the absence of evidence (Cook et al. 2013). In medicine, critics of evidence-based practice suggest that more attention should be paid to the critical role of expert judgment in clinical practice (e.g., Tonelli 1998).

Expert judgment can be a necessary element in determining what public-regarding ends to pursue, and by what public-regarding ways. Following Sullivan and Peters I suggest that the insights from this research can help reveal how individual scientists are willing to engage more than just their technical skills, and likely even more than just their professional scientific knowledge, towards addressing complex social-scientific interests such as conservation. The narrative excerpts shared here invite us to consider ways that human judgment can be exercised by scientists to see creative opportunities for integrating their scientific interests with broader social concerns for conservation. They help us to appreciate how individual scientists may be welcoming, or even actively seeking, opportunities to more fully express and exercise their human interests and interactions as part of their careers in science.

Seeing pathways such as those articulated here, along with the scientific and social opportunities associated with them, can open up new possibilities for consideration as appropriate practice for research and conservation. They can enrich our understandings of the interests of scientists as individuals, and of the ways scientists perceive and pursue those interests. As these individuals draw upon practical theories to address conservation targets that have explicit implications for public interests, questions can be asked about the ways they may be stepping into new roles that are unsupported, unregulated, and (often) underappreciated. Important, albeit difficult, questions emerge as well about the role of evidence in informing conservation action, and about roles for scientists in the public sphere.

In Chapter 4 I expand this inquiry from what individual scientists consider as meaningful and possible, to the work and roles individuals take up in pursuit of such possibilities.

CONCLUSION

Reading these scientists' narratives, and recognizing their nuanced pathways to conservation, reveal ways that social elements, and exercising judgment, are not in opposition to producing good science. As such, these narratives can help expand the often-simplistic considerations about how scientists as experts perceive and pursue complex social-technical problems. The narratives of these scientists suggest that citizen science may be one means of "something else" that can be done to more effectively address social as well as scientific outcomes and processes. Narratives such as these can help other experts recognize, discuss, and consider alternative pathways for addressing the socially complex concerns of conservation.

What we don't see and what we don't talk about, we can't recognize and appreciate. What we don't understand as possible, we won't try to pursue as an option. These scientists are seeing social-ecological outcomes as within their purview, and are articulating practical theories towards affecting them that show a willingness to engage social aspects of these issues. These are purposes and possibilities that can seem unexpected for scientists, and that they don't get credit (either socially or institutionally) for pursuing. The narratives of these scientists reveal ways that professional scientists might forge paths towards meaningful ends not *instead* of their science, but *through* their science – science done in ways that recognize and engage the social aspects of complex concerns. These insights invite further investigation of the outcomes from citizen science, and further consideration of the roles scientists take up in the pursuit of such possibilities.

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CHAPTER 4

"I TRY TO WORK WITH THESE PEOPLE." SCIENTISTS, CITIZEN SCIENCE, PUBLIC ENGAGEMENT, AND CONSERVATION

ABSTRACT

There is an increasing awareness that conservation calls for both rigorous science and public engagement. Scientists working with citizen science have the opportunity to connect with public participants in their projects, but it can be difficult to reconcile public engagement roles with the traditionally expected roles of scientists as impartial, technical experts. Early work suggests that scientists have interests in affecting integrated social-technical outcomes through their citizen science work (Shirk Chapter 3). I turn to narratives of practice that can help elicit and reveal the roles scientists take on when engaging the complexities of conservation as a socially mediated process. These narratives can also help us imagine new ways to do – and appreciate the work of scientists towards – conservation as both a relational and a technical practice.

INTRODUCTION

An increasing number of scientists are conducting investigations that rely on or support public participation in scientific research. Hereafter referred to as citizen science, these initiatives may also be known by such terms as volunteer monitoring or community-based research. All share the element of generating new science-based knowledge for research or management through the engagement of public volunteers (Shirk et al. 2012). Scientists and scholars have increasingly accepted such approaches, both for their ability to access information at an otherwise unfeasible scale (Dickinson et al. 2010, Bonney et al. 2009*a*) and their ability to affect public science learning (Zoellick et al. 2012, Bonney et al. 2009*b*). In natural resources fields, there is also the potential for these initiatives to affect conservation outcomes (Dickinson and Bonney 2012).

However, influencing conservation is a complex practice, and one in which the role of science and scientific experts can be contentious. Involving the public in research can heighten the potential for a wide range of critiques. For one, conservation needs to be informed by rigorous science, and any work with the public can be seen as taking time away from, or even biasing, scientific research. At the same time, public stakeholders can see attentiveness exclusively to scientific or technical priorities as insensitive to diverse social values, fueling mistrust of scientists' intentions (Yamamoto 2012, Wynne 1996, Berkes 2004). Given this complexity, it can be challenging for scientists to find meaningful roles to play in the socially-embedded work of conservation.

Thought leaders in conservation are calling for new role models for how scientists might more effectively engage with the public, suggesting that the traditional "expert" role of disseminating information is insufficient to address conservation concerns (Palmer et al.

2005). Exploratory work in citizen science reveals that some scientists see possibilities for achieving socially-minded conservation outcomes by engaging the public through far more complex pathways, inviting broader consideration of the social as well as technical responsibilities of experts (Shirk Chapter 3). Here, I build on those insights to explore the ways these scientists *are* engaging with the public in citizen science, potentially in unexpected ways. Specifically, I ask:

> Q1. Through their narratives of citizen science involvement, what roles can we see scientists stepping into in relationship to the public?
>
> Q2. In what ways can we see scientists encountering and navigating tensions between roles working with the public and their professional interests, identities, and roles as scientists?

I explore these questions within a broader literature regarding social and relational work of experts. In particular, I confront the presumption that scientists' credibility hinges on remaining detached, objective, and autonomous. I suggest that this investigation can help us expand considerations of appropriate roles for scientists through which they can productively engage complex social-scientific concerns.

ROLES FOR SCIENTISTS IN CONSERVATION AND PUBLIC ENGAGEMENT

Roles in conservation

The field of conservation biology is founded on an understanding that scientists can and should have roles to play in the complicated, socially embedded enactment of conservation (Barry and Oelschlaeger 1996, Meine and Meffe 1996). Throughout its 20-plus-year history, the field has struggled with questions about the roles scientists play in addressing socially complex crises of species decline, advancing invasives, habitat destruction, and a litany of other pressing concerns which technical knowledge has only gone so far to address. In the inaugural issue of *Conservation Biology*, Soulé (1987) notes, "As conservation biologists, our major role in this movement is a scientific one...."

However, he continues, "... though some of us may take on other jobs in the conservation movement – as publicists, as advocates, as activists, and mentors." Scientists work to influence conservation through a wide range of roles, institutional contexts, and domains, and yet some roles that may be taken up by individual scientists can be perceived as in conflict with professional scientific work. In many traditions, expectations of scientists are for the autonomous production of objective knowledge, while any work to influence change based on that knowledge is the responsibility of other professionals such as politicians, educators, or managers (Lundberg 1961 via Peters 2010). Such traditions and expectations can result in personal and professional tensions when individual scientists believe that evidence of conservation crises compels action.

Take, for example, the ongoing debate in Conservation Biology regarding scientists serving in advocacy roles (see, for example, Meyer et al. 2010, Nelson and Vucetich 2009, Lackey 2007, Freyfogle and Newton 2002), despite growing consensus that conservation biologists can (or by some accounts, inevitably *do,* per Wilhere 2011) advocate for conservation action. Debate over whether scientist *should* engage in advocacy may oversimplify the realities as to what happens when scientists actually do take on advocacy roles. Lach et al. (2003) bring attention to ways this debate may oversimplify the work of advocacy, questioning assumptions that advocacy will either, a) damage scientists' credibility or, b) result in more informed conservation decision making.

Steel et al. (2004) consider advocacy, among other roles, as part of a study investigating the attitudes of diverse stakeholders regarding Long Term Ecological Research (LTER) scientists' roles in policy-related research. Based on LTER Pacific Northwest, Steel, Lach, and colleagues identify five "ideal type" roles for scientists in the policy-making process (Table 5). Scientists and managers in the study had negative attitudes about scientists advocating for or actively making policy decisions, citing particular questions about scientific credibility. But both scientists and the public were amenable to what Lach et al. (2003) refer to as "non-traditional" roles for integrating science and management concerns.

Table 5. "Ideal type" roles for scientists in environmental policy decisions, as described in Steel et al. (2004; see also Lach et al. 2003).

ROLE *... it is appropriate to ...*	**INTENTION** *... in order to... .*
Impartial expert *(Report results)*	Make information available for policy-making.
Translator *(Interpret results)*	Make information accessible and understandable for policy-making.
Collaborator *(Integrate results)*	Make a space for science in management activities.
Advocate *(Promote decisions based on science)*	Influence policies to reflect scientific insights.
Technocrat *(Make decisions based on science)*	Ensure that decisions reflect the technical complexity of science.

The “non-traditional” aspect of these roles, from the authors’ perspectives, has to do with relationships. Unlike more traditional roles described in the study, where scientists *report* or *interpret* knowledge they produced in collaboration with scientific peers, more integrated work means scientists, “... will also have to learn to work more effectively with agency personnel and managers, public interest groups, and the public” (Lach et al. 2003). This suggests that in order to impact conservation, scientists may need to consider a role for more relational work, which Edwards (2010) describes as, “... being able to negotiate interpretations and responses to complex problems that incorporate what others can offer.”

The thought of incorporating the work or insights of “others” can seem antithetical to traditional premises of scientific work. Scientific credibility, in particular, is often understood to depend upon scientists’ detachment from public interests or concerns, and is an attribute that many institutional standards and cultural norms have been established to safeguard (Cash et al. 2002). These very norms, however, can serve to complicate conservation work that demands at least awareness of, if not attention to and engagement with, the values and interests of policy makers, the public, and even scientists themselves (Barry and Oelschlaeger 1996). The Pacific Northwest study by Steel et al. brings attention to social, cultural, and institutional expectations and pressures that heavily influence LTER scientists’ decisions about how to engage in socially complex issues (see also Lach et al. 2003). We are beginning to see the influence of these norms play out not just in the policy-making arena, but in regards to recent calls for conservation scientists to be more (and more meaningfully) engaged with the public (Palmer 2012, Chapin et al. 2011, Palmer et al. 2005).

Public engagement

Public engagement is a concept with widely disputed definitions, but in general terms is increasingly embraced by scientists and scientific institutions (whether enthusiastically or begrudgingly). Some consider any work with social relevance, even basic research that explores societal problems, to be publicly engaged work (e.g., Whitmer et al. 2010). Here, I address work that specifically engages scientists *with* the public. Citizen science has been identified as one form of that work (CAISE 2014, Groffman 2010), but within and around citizen science activities, scientists can engage (or not) with the public in a wide range of ways.

For some, public engagement is considered simply in terms of communicating and disseminating knowledge (e.g., Kuehne et al. 2014, Whitmer et al. 2010, Polkiakoff and Webb 2007), such as the "reporting" and "interpreting" roles described by Steel et al. There has been significant high-profile support for and investment in science communication activities (e.g., AAAS 2013, Lubchenco 1998). Research suggests that even this basic (albeit neither easy nor unimportant) approach to working with the public can be hampered by institutional and cultural traditions including reward structures; perceptions of appropriate roles for male and female scientists; and limited peer modeling or mentorship (Johnson et al. 2013, Jensen 2011, Poliakoff and Webb 2007).

A broader consideration of public engagement invites scientists to look beyond information dissemination and the so-called "deficit model" of education (McCallie et al. 2009, Bucchi 2008). McCallie et al. (2009), in an inquiry into public engagement in science work in informal science education, bring particular attention to formats that encourage multi-directional engagement among many stakeholders about social-scientific topics. Such activities include science cafés, public forums for dialog and deliberation, and citizen science. Similar to Shirk et al. (2012), they call for attentiveness to the degree and quality of public participation in these activities. Effective engagement elements they describe include:

- "Mutual learning by publics and scientists, allowing all participants to develop new or more nuanced understandings of issues and opportunities; ..." and,
- "Recognition of the importance of applying multiple perspectives and domains of knowledge, including scientific understandings, personal and cultural values, and social and ethical concerns, to understanding and decision making related to science and to science-related societal issues" (McCallie et al. 2009).

Taking part in public engagement activities that involve more relational elements such as these may be difficult to for some scientists to imagine. However, the ideals informing these approaches have a long history in certain scientific traditions and contexts. Scott Peters (2010) highlights the influence of late 19th- and early 20th-century scholars on scientists' public engagement traditions in higher education and the land-grant system. Among them, foundational figures in science and science education, such as John Dewey and Liberty Hyde Bailey, suggest that scientists not only can but *should* have active and engaged roles with the public, roles described in terms that reveal social and even democratic interests. A selection, from the literature, of more publicly engaged roles for scientists is offered in Table 6.

Suggestions of such deeply democratic and engaged roles can challenge the ideals of autonomy and objectivity that many associate with science. Some scientists may therefore worry that engaging with the public could jeopardize their credibility as

Table 6. From the literature, a selection of roles outlined for scientists in relationship to the public and conservation or environmental issues, as described by various scholars of science and conservation. Many of these roles are not named, perhaps because they are largely unrecognized and not codified within social or scientific circles.

ROLE *... it is appropriate to ...*	**INTENTION** *... in order to... .*
Teach students of any age	ensure that future generations, "have the necessary knowledge, attitudes, and skills to make decisions that take ecological knowledge into account." (Palmer et al. 2005).
"listen and respond to the needs of society"	Help inform priorities and agendas for science (Palmer et al. 2005).
Facilitate public learning	Build capacity for asking and answering questions of concern (Fischer, p. 182).
Foster a "scientific attitude"	Ensure a more democratic society (Dewey 1939).
Make a space for citizens in the process of knowledge production	"build positively on citizen experiences" (Irwin 1995, p. 175).

experts (Jasanoff 2003, Lach et al. 2003, Pace et al. 2010). Lach et al. (2003) explored perceptions of credibility for scientists in the aforementioned roles in the Pacific Northwest, and found that credibility, rather than being assessed by methods of data collection and analysis, is assessed by both managers and the public as a factor of the usability of information and the means by which that information is communicated.

Public engagement for conservation

In the "crisis science" of conservation, the question is now not one of whether, but rather *how* scientists choose to work with the public (e.g., Irwin 1995). There is certainly important work to be done by scientists disseminating their knowledge to the public (e.g., Kuehne et al 2014, Groffman et al. 2010). But conservation psychologists and education scholars are clear that sharing knowledge is insufficient to affect conservation action (e.g., Schultz 2011).

Some in conservation think that change demands more “revolutionary ecology,” described as “... ecological research that catalyzes social action to improve environmental conditions and societal welfare ...” (Colón-Rivera et al 2011). Similar, if slightly more moderate, moves towards Earth Stewardship (Chapin et al. 2011) and actionable science (Palmer et al. 2012) in ecology call for scientists to “listen and respond to the needs of society” (Palmer et al. 2005), and to “engage in dialog involving diverse human values” (Chapin et al. 2011). Such activities are a move beyond the detached work of scientists in “reporting” or “interpreting” roles as described by Steel et al. (2004), and can be challenging for scientists to imagine within traditional research careers and settings.

Scientists may also reasonably ask how they can do any kind of public engagement work alongside their research, given institutional constraints and disciplinary expectations that can weigh heavily against it (e.g., Johnson et al. 2013). Taking on more relational roles in public engagement can challenge traditional reward structures (Bazzaz et al. 1998) and may likely also move scientists out of their comfort zones (Palmer et al. 2005, Palmer 2012, Whitmer et al. 2010, Colón-Rivera et al. 2013). Cash et al. (2003) suggest that sustainability research, a similarly social and relational practice, may call for a, “... truly radical contract... for whole professional careers.”

But maybe it doesn’t have to be radical. Some scientists are voicing practical theories that their citizen science research can provide a pathway to meaningful social and conservation outcomes (Shirk, Chapter 3). To enact these theories, I suspect that they are likely stepping into surprising and more relational roles than are generally expected of scientists, roles that may help them integrate their science with social concerns for conservation. It can be useful to know what it looks like when a scientist takes on a public engagement role, and what it involves and requires in order to make that work as part of professional scientific practice given presumptions. By investigating scientists' roles in citizen science, and the way they articulate the meaning of those roles for conservation purposes, we can broaden consideration of both what is happening and what is possible for scientists despite sometimes constraining expectations and traditions.

RESEARCH APPROACH

As part of a larger research effort to explore how scientists are able to make citizen science a successful part of their careers in conservation research, I explore here the roles that scientists adopt as they engage with the public in conservation research through citizen science. Following Lach et al., I suspect that considerations of public engagement, similar to considerations of advocacy, may oversimplify the implications for scientists who are thinking about and/or actively undertaking this work. This inquiry aims to move the conversation beyond categorical understandings of "ideal type" roles, to explore what individuals can show us that might enrich, complicate, and challenge our understandings of actual roles scientists can fill in addressing complex problems.

I specifically consider the unexpected roles that scientists name and fill, and the unconventional work they do, as part of their citizen science practice. Roles that challenge institutional expectations can sometimes be difficult to name, or even recognize. Therefore, I turn to narratives as a means of eliciting reflections on practice, exploring the roles that are revealed through work described, and revealing detail that can help theoretical and categorical understandings come to life (Forester 1999).

Narratives and science

A 2013 paper by Leslie et al. (2013) invites consideration of the value of narratives for conservation, including narratives as a source of data. Narratives are a natural and powerful currency of communication, which can reveal things that are, as Polkinghorne (2007) expresses it, “neglected, but significant.” People use narratives to process their actions and to explain or justify (to themselves and others) their sometimes-difficult choices (Chase 1995, Moore et al. 2005). Narratives can provide a means of reflexive practice, an opportunity to consider not just what works or what doesn’t work, but what *matters* (Freeman 2006, Forester 1999).

Narrative research can provide insight into how people understand, pursue, and find meaning in their work (Peters 2010, Forester 1999). This research approach – of soliciting and interpreting narratives of practice – is increasingly employed in a wide range of fields including public planning, nursing, and higher education (Chase 2011, Clandinin 2007). In the practice-focused field of conservation, narratives can help address the need to move beyond an oversimplified consideration of scientists’ roles in public engagement. Specifically, I employ narrative research to understand and interpret the meaningful roles scientists describe taking on through their citizen science work. Through narratives, I consider the tensions and challenges scientists’ describe between their roles and identities in scientific research and in public engagement, as well as the ways they navigate those tensions.

Narrative interviews

I conducted in-depth, narrative interviews with nine scientists who understood their work with the public as fitting within the recently defined field of practice, Public Participation in Scientific Research (Bonney et al. 2009). PPSR is defined as, "intentional collaborations in which members of the public engage in the process of research to generate new science-based knowledge" (Shirk et al. 2012; hereafter referred to as citizen science). I sought scientists with PhDs in conservation-related fields, who demonstrated sustained involvement (5 years or more) in ongoing and/or successive citizen science initiatives. Together, these criteria suggest professional investment in – and dependence upon the success of – the research aspects of their citizen science work.

Individuals interviewed represented diverse professional settings, including management agencies, research universities, and non-profit research institutions. I focused on individuals working in four research domains, recognizing great diversity across the work of each individual within these domains: bird research, sea turtle research, water quality research, and butterfly research. Within each domain, I interviewed individuals whose work spoke to different approaches to public participation (per Chapter 2, Shirk et al. 2012).

Interviews took place over three, and in one case four, phone calls or in-person sessions. With each individual, interviews cumulatively lasted between one and a half and three hours. A semi-structured script (Appendix B) positioned opening questions in the context of events and activities, and specifically invited storied, narrative accounts (e.g., "how did this work begin?"). Additional prompts encouraged details on how each interviewee approached their work (e.g., "how did you deal with that?" and "what did you do then?"). The final interview with each individual concluded with an invitation for reflection on the relationship between citizen science and conservation and/or management. All interviews were recorded and transcribed (Forester 2006, Chase 1995).

Following Forester et al. (2005) and Peters (2010), I constructed a story of practice for each scientist by editing together discrete interviews, removing my own voice and any redundant passages, and crafting a cohesive first-person narrative. As one means to enhance validity, each interviewee was encouraged to review their story of practice as well as the resulting findings, and relate any concerns or misgivings about interpretations. The resulting narratives are available in Appendix C.

Interpreting narratives

There are many different scales at which narrative work can be interpreted, and here I attend primarily to "big stories." Freeman (2006) suggests that big stories offer sufficient distance and reflection to reveal how roles and identities unfold and are established. Our interviews sought to investigate the citizen science work of these scientists, and revealed many relatively smaller stories of day-in and day-out activities, but narratives in many cases took the form of accounts of scientists' entire careers. As I am investigating the roles that scientists are able to take up *as part of* their careers, I look to the larger narratives of practice to make sense of roles that they express as sustained or evolving within that context.

Within these narratives, I pay particular attention to *narrative identities* (McAdams, Josselson and Lieblich 2006 via Chase 2011), individuals' "internalized and evolving life stories." This includes the roles and identities these scientists ascribe to themselves, as well as the roles we can see them taking on, as they engage with the public through their citizen science work.

Given that "big stories" unfold slowly and expansively in the words of each interviewee, here I summarize certain elements of narratives (see Dodge et al. 2005). For most, this involves our setting the scene and introducing the key player(s). I share narrative excerpts to help reveal action (albeit action that may unfold across a sequence of excerpts) and resolution (to the degree that any ongoing narrative can be considered "resolved").

In the next section (Findings), I provide excerpts of larger narratives from three of the scientists interviewed, through which we can see far more nuanced understandings of roles in action than categorical "ideal types" of roles convey. In that section, I consider what those excerpts reveal . In the final section of this chapter (Discussion), I look at those insights in light of literature on public engagement, conservation, and the professional work of scientists. In that section I explore how these narratives can enrich and complicate theoretical understandings of appropriate roles for scientists in relationship to the public.

FINDINGS

There are plenty of reasons for scientists to be concerned about taking up additional roles for conservation, including concerns for the validity of scientific work, for credibility among peers and among the public, and for authority in informing decisions. Despite all of that, there are scientists who are taking on unexpected, publicly engaged roles as part of their citizen science work. The excerpts shared here help provide active and personal insights into otherwise categorical roles, as well as how people navigate concerns in taking up those roles.

Q1. I share and discuss excerpts from illustrative narratives of three scientists who specifically describe taking on public engagement roles that shake up expectations. I consider one role that we may think we understand (Activist), to explore how that role may look quite different than more traditional definitions and perceptions in scientific spheres. I also share two narratives that reveal scientists stepping into unexpected roles (Mediator and Network Broker), and look at how those roles manifest within each individual's career.

Q2. In considering these roles, I attend to how scientists understand the significance of their roles in regards to conservation purposes, and explore what each role might offer to and require of scientists. In these narrative excerpts, we begin to see scientists evidencing an appreciation for relational work. Traditional considerations of scientific practice would have us expect that relational work would challenge scientific credibility. These narratives show us a more complex picture, where building relationships can raise tensions but may also enable new kinds of research and conservation work.

Activist as facilitator

Identity and personal history play a large role in the story Candie Wilderman tells about her work with the ALLARM project that she launched in 1986 (originally the acronym stood for Alliance for Acid Rain Monitoring, now Alliance for Aquatic Resource Monitoring). At time of interview, Candie was Professor and Chair of Environmental

Sciences at Dickinson College in south central Pennsylvania. Early in her story about the evolution of ALLARM, and its initial goal to seek patterns in acid rain episodes, she interjected, “I don’t know how to put this, but I have always been involved in social activism.”

In the conservation biology literature, the role of activist is discussed almost solely in regards to non-scientists. The role of advocate – similar in its attention to influencing policy and action – has as previously mentioned received quite heated debate in the field, and as reported by Steel et al. (2004) received regional skepticism from scientists as an appropriate role to play. Many may presume from this, then, that being an activist is yet even more *risqué* for a scientist, with similar if inflated negative implications for credibility.

Before making assumptions about this terminology and role, it is worth considering other understandings of the term, including Candie’s own understanding of and approach to activism and how that plays out in her career. In the mid-1970’s, Candie was moved to leave her graduate program – at Harvard, working with Stephen Jay Gould – to join the VISTA (Volunteers in Service To America) program in Kentucky. There, she was trained by the Office of Economic Opportunity in a philosophy of community capacity building, which she credits as influential in her approach to ALLARM at a critical moment in its history.

Candie had initiated ALLARM to recruit volunteers statewide to collect data on acid rain. That approach worked better than she had ever anticipated, but she also started hearing other concerns from volunteers across Pennsylvania:

…we were training them on pH and alkalinity, and people started saying, "well, you know something, what I'm really concerned about is the hog farm up the stream. And I don't really care that much about acid rain,".... and we began to realize that we could reach more people and address more issues by using the model of working with groups on their agendas than we could by working with individuals on the single issue of acid rain, which was our agenda.

And now the goals of the projects have changed. I would say that the model we've been using, when we became Aquatic Resources as opposed to Acid Rain… you know, the acid rain project had an agenda that was set by the professionals, so to speak. I mean, there's a problem – acid rain – we want to study it, we want to document it, we want to contribute to a database and so on. And we want to be able to document patterns. ... So the goal was very clear, and, in their minds, what they felt was, "we are contributing to a database that is established at Dickinson College, and those guys are analyzing it and there's going to be interesting research that comes out of it." And they were ok with that.

The role Candie positions herself in at this point in ALLARM's evolution – naming the problem, setting the research agenda, and leading the research process – falls in line with the traditional and anticipated roles and activities of scientists as knowledge producers. This may be the role most commonly presumed of scientists engaging the public through citizen science. Such a role is implied in contributory approaches to citizen science as described by Shirk et al. (2012; Chapter 2), although the authors are careful to point out the fluid and adaptable nature of project approaches to participation. In fact, ALLARM is described in that work as an example of a co-created project. Candie's narrative goes on to reveal how the approach to project research changed as ALLARM shifted to accommodate concerns raised by the public:

> *Now with the new project, the goal was much more problem solving at the local levels, of a problem that they're concerned about. It was problem solving, it wasn't research. I mean, you need to do a certain amount of research to problem solve, and we needed to collect the baseline data to understand, to document what the problems were, but our real goal was data use in problem solving. And that's a little bit of a different kind of research… it's not really scientific research that would be particularly interesting to anyone but people in the watershed, or scientists in the watershed. Now that's not to say that a scientist couldn't jump in and utilize the data across watersheds and find some interesting patterns and do some data crunching and some interesting analysis that would be publishable in scientific journals that would show some patterns or answer some questions, but that's not really the goal of the project. ... They're all action-oriented kinds of goals, and the data collection is more towards problem solving, things like, "we want to change the way land is used, we want to change the zoning, we want to upgrade the stream." They're addressing policy issues as opposed to, "we want to do scientific research."*

Such a shift had implications for Candie's own role. As Candie shares the evolution of the ALLARM project, we can see her begin to describe her work as supporting communities in designing, conducting, interpreting, and making change through scientific research. Candie outlines this in relationship to a series of workshops ALLARM conducted with a single watershed organization to help them through the entire research process.

> *... we explained, "well, the first thing you need to do is you need to figure out what your goals are, you need to put together a study design, you need to figure out what your resources are…." We basically started with a study design where we went out there, and once a week for a few months we facilitated a discussion with them on what might be the questions that they're asking, what might be their goals, and how they might accomplish that in terms of monitoring.*

In these, we can see resonance with an alternative consideration of "activist research." Writing for the Social Science Research Council, Hale (citing Stokes 1997) describes "activist research" as "use-oriented basic research" (2001). He writes, "activist research requires a process of dialogue and collective work," and outlines the necessary involvement of stakeholders (in his case, the subjects of social science research) throughout the process of determining research questions, collecting data, and both interpreting and using results. His intention is that, "... by participating they [stakeholders] will enrich the analysis, and also take possession of the results in ways that could be useful for their own purposes."

Furthermore, while Candie's use of the word "activism" may conjure certain images, the most frequent active verb Candie uses to describe what she actually does is the word "facilitate." Picking up on her use of this term, we suggest that her role may also closely align with Frank Fischer's (2000) description of a scientific expert as a "'facilitator' of public learning and political empowerment." Fischer calls for experts to help build capacity for citizens to ask and answer questions of concern, inviting the question of what it might actually look like for a scientist to take up a role that seems so counter to the idealized expectations of scientists as impartial, and as in charge of the process of knowledge production. In practice, Candie shares that, "... the whole thing about building community capacity, and allowing communities to set the agenda and working with a bottom-up model, requires that you be responsive. It's our philosophy, it's very intentional."

One reason to understand how such a role might play out for an individual is that Fischer is explicit about the political nature of his call for experts to become facilitators of public learning. He argues that rather than endangering credibility, the legitimacy of public participation in policy decisions is enhanced by the facilitation of a credible expert. Candie shares instances of ALLARM groups using their data to effectively ban power plants, change zoning regulations, and testify to state legislature.

However, taking on a politically-minded role such as this can raise questions from scientific peers about the validity of the knowledge produced. Candie acknowledges that this "bottom up" approach (Wilderman et al. 2004) for her does generally result more in public engagement and action than in publishable scientific research. But she reveals her identity and her interests as she shares how she has prioritized and justified taking on the activist/facilitator role:

> *... if I were a research scientist, I probably wouldn't be very comfortable with this ["bottom-up"] model. But I'm not a research scientist and I'm very comfortable with this model because I'm interested in seeing social change, and I'm interested in seeing public education. And I feel that this model feeds into that interest.*

In so aligning her identity, Candie reveals her own acknowledgment that it is unconventional for a "research scientist" to take up a role that aligns with social action. She describes how her position at a liberal arts institution – even her position as Chair of the Department of Environmental Sciences – may have uniquely, if not easily, enabled her to pursue her interests in these ways:

> *… it was very difficult to convince my dean that this was scholarly work. Or that this was something appropriate for a scientist to be doing. At that time I had just finished my PhD dissertation, which was on diatoms as water quality indicators, and I was doing some publishing in the diatom literature. My dean very clearly said to me, "well, this ALLARM stuff is interesting, but it's service work, it's extra curricular, you'd better keep publishing about diatoms." And I thought, "you know, five people are reading these articles about diatoms and they don't even understand it, why am I … [laughing]?" I just didn't feel like this was what I wanted to do with my time. And so I just decided I was going to pretty much shift my scholarly activity into ALLARM, which I did, and ultimately the college was convinced.*

In Candie's full narrative (in Appendix C), she shares more complicated details as to how "the college was convinced," which was not a simple process. It is important to recognizing the tensions, as well as the opportunities, that this kind of work can raise for scientists. Given this, I suggest that Candie is exercising agency to step into a role that enables her to bring her personal interests into alignment with her professional pursuits, as well as with the interests of the communities with which she was working. Candie's narrative helps us to begin to see scientists as autonomous agents, not just detached technical actors – individuals who have both interests and expertise that, through thoughtful work, can benefit people.

Mediator

Dan Canfield, Professor of Limnology at the University of Florida and founder of Florida LAKEWATCH, introduces his project in very inclusive terms, saying, "I'll call ourselves the volunteer firemen of water." From the outset he shares, "I'm an applied person, that's there trying to solve a problem," and it is clear throughout his story that he doesn't flinch at tackling difficult problems or confronting controversial issues.

Dan reflects that his LAKEWATCH initiative was founded in the 1980's during a time of increasing awareness of environmental concerns. He shares:

> *I was sitting in my office and some citizens from Santa Fe Lakes came in and said they wanted help on their lakes, and I told them I didn't have staff or money to do it. They said, "we'll do the work, you just tell us what to do." And I thought about it for a little bit, and I got thinking, "well, I get graduate students right out of college who know virtually nothing, and here are CEOs and presidents of companies asking me to do this, and they said they can learn." So I said, "well, I guess they can learn," so I started training them to do the simple stuff...*

LAKEWATCH now involves volunteers across Florida in various activities related to monitoring water quality, from collecting water samples for professional lab analysis, to taking Secchi disk readings of water clarity, to taking detailed field notes that inform later analysis of trends. Dan shares:

> *... what I think our public wants, [is] to fix the problem, if there is a problem. But they're very open-minded at the beginning, as to what's the problem. Ok, make the problem the hypothesis, and we'll collect the data and either accept or reject that hypothesis. And the public likes*

> *that. They see it as puzzle-solving. And then if there is a problem, I'll walk in – they have an insurance policy if something does happen.*

In his story, Dan regularly expresses respect for the insights and questions that volunteers have shared with him over the 30 years of the program. At times, he speaks as if he would prefer to identify more with the public than with his scientific peers, and that this may have influenced his choice to do more citizen science work:

> *... one of the big compliments to me was from the citizens out there: "well you don't seem like a university professor." What does that tell you? What do they think about professors? No, I don't want to seem like an egghead PhD, "I'm right, you're wrong," operation. I try to work with these people. I have more experience, I have more – whatever – in the field of limnology, but they also have insights.*
>
> *... We professors today have a lot of baggage in the eyes of the general public in certain ways. So when they say, "well you don't seem like one," that's good to me. It's a lot of different things going on in people's minds. But on my research end, I do a lot of research that – we're testing hypotheses, and the data supports or doesn't support, and so a lot of my papers tend to be controversial. With a lot of these lake management issues where my views differ from the conventional wisdom, my opponents sometimes say, "oh, he's a rogue scientist," in an attempt to demean me. Well, no, we deal with the data and publish the papers, and we'll see where science takes us in the years to come. But I'm putting out the way I interpret the data. I don't worry about what people think about me.*

In a slight contradiction to this final statement, I propose that Dan does seem to care that "the citizens" he works with see him as someone they can relate to – which he describes as in contrast to most scientists. He suggests in this excerpt that he is able to, at once, acknowledge the relevant insights of citizens, engender their trust, and stand by the potentially controversial implications of his technical research – a combined set of characteristics that seem difficult to accomplish together.

We can gain some insights into how Dan might achieve this by seeing him talk about a role he takes up in a related project. In addition to LAKEWATCH, Dan manages a related initiative that directly engages the public and scientists in determining a plan of action around controversial issues. He calls this the TEAM Approach (Together for Environmental Assessment and Management; see also Canfield and Canfield 1994):

> *... we bring in citizens from all walks of life and of all different viewpoints. We sit them in a room for a day, and say, "what do you see as the problem?" And they start with 10 million problems, but by the end eventually it comes down to four or five problems. And then we take that (the four to five problems) to the scientific community, and I'm saying, "ok, what do you see as the problem with what the citizens are saying?" And then that forces scientists to say, in a written document to the public, "ok, where do you agree, where do you disagree, and when you disagree, why?" And write it in 6th grade language so the citizens can understand it (forget the big technical words). We'll go back to the citizens, and they're very good at saying, "well this is the way we think we want to solve our problem, to manage the lake," and you end up with a majority view and a minority view. So you say, "ok, we'll monitor for what the minorities are concerned about, and if the data begins to support the minority view, you could always change your plan up." But a lot of times, it's not that hard a subject. You can prevent a lot of problems at the lakes by involving the citizens, because – there's a fellow by the name of H.A. Simon that says, "If you expect significant*

changes in the behavior of people, you better have them involved in making the decision for that change."

Although contentious situations arise routinely in conservation contexts, little is written about scientists taking on roles related to mediating conflict. Without describing a *role*, Niemelä et al. (2005) describe three different approaches to managing conservation conflicts and the focus of the efforts in each: technical (substance), political (procedures), and cultural (relationships). Norms might suggest that a scientist would approach conflict from a technical perspective to tackle the substance of the problem. However, Niemelä et al. suggest that scientists can often be put in the complicated position of taking up multiple roles in conflict situations.

We can see Dan touching on all three elements of the conflict management approaches described by Niemelä et al. As a whole, the TEAM Approach is a *procedural* means to addressing conflict. TEAM specifically focuses stakeholder conversation on *substance* by coming to a shared understanding of the problem. Dan also attends to the *relationships* among diverse stakeholders and between stakeholders and scientists, as we can see in his following reflection:

> *The other thing is, you know, I think a lot of our folks – scientists – are adverse to conflict. They see conflict as very difficult, and I see conflict as something that is creative and simple to deal with – conflict resolution comes down to the following three things: one, "Did I get what I wanted? If I got what I wanted, then there's no conflict, right?" Two: "Was I treated fairly?" No person likes to be treated in an unfair operation, like saying, "you're an idiot" or whatever. You just gotta work with them and say, "ok, your concern is a hypothesis, a working*

hypothesis." You don't just discount them. And three: they gotta know the process is fair. If they think the process is unfair, they'll come in at the last hour and fight you tooth and nail forever. So really, to resolve the conflict, you only need two out of those three things. The TEAM approach is to make it as fair as they can, and then treat the people right, so you got two out of the three. So nine times out of ten, when we're done with these TEAM meetings, people accept it. And then the minority hasn't been thrown overboard, they say, "ok, we're gonna monitor for this stuff." So I see a lot of direction related to how we'll work more closely with the people again. Rather than getting away from it, which is what a lot of groups have done.

Dan describes a very active and multidimensional role in mediating conflict, even as we hear him suggest that this is not a comfortable role for many of his peers. It can be unexpected to hear a scientist talk about being attentive to relationships and willing to engage the concerns and values of individuals, particularly around contentious issues.

Working as a mediator at the boundary of values and of science, Dan has been mindful of his own identity as a player in several controversial issues. In some of his research, the technical facts were at odds with the desired outcomes of some stakeholders (see, for example, Canfield et al. 1993 on the Rodman Reservoir Controversy). Dan notes the need to insulate the LAKEWATCH monitoring program from his controversial persona:

LAKEWATCH is viewed very positively by virtually everyone. And in part that's because I don't tout myself as the leader and director of LAKEWATCH. I try to keep my controversial research stuff separate, and over time, people will find out who I am. But a lot of times they don't recognize who I am. I mean, I've been involved in things like the eutrophication of Lake Okeechobee down here, Lake Apopka, Rodman

Reservoir – big controversial issues that the environmental community, for example, is promoting. Then I come out and say, "wait a minute, you got no clothes on, this is wrong," and people get upset about it because they think I am not concerned about the environment. But they didn't really realize that I was running the LAKEWATCH program all the time....

Dan's penchant for engaging in controversial issues is held in tension with his interest and role in mediating conflict. Seeing this invites questions about how scientists might serve as mediators if their own science is perceived as in conflict with social values. Standing by technical research results, particularly research that has bearing on a controversial issue, can thrust scientists unexpectedly into a political position.

In regards to such complexity, we can see Dan positioning science itself as a mediating process. He describes working with concerned individuals to articulate issues in terms of hypotheses around which they can conduct monitoring and evaluate change through data. Synthetic work on public participation and policy suggests that bringing together data analyses with public deliberation, if done well, can be a productive way of expanding a more traditional science communication role to engage social values (Dietz 2013). Dietz cautions specifically, however, that "... trust is not well served when scientists confuse competencies," clarifying that the public needs to be clear about when scientists are speaking based on facts or on their values.

It is worth remarking on Dan's earlier invocation of Herbert Simon, a political scientist and organizational theorist who introduced the concept of 'bounded rationality.' In contrast to 'technical rationality,' bounded rationality (Simon 1982) emphasizes seeking satisfactory rather than technically optimal solutions. The concept recognizes the inherent uncertainty and change in complex systems, and acknowledges that social values have a role to play in prioritizing what counts as satisfactory outcomes. However, it is worth a cautious assessment of how technical perspectives may end up being prioritized in relationship to values, through this approach of monitoring and accounting. Ultimately Dan speaks of TEAM and LAKEWATCH both as providing means to *resolve* problems, or to *help* solve problems, acknowledging science as just one player in the landscape.

Network Broker

J. Nichols, a marine ecologist based at the California Academy of Sciences, started his citizen science work through an Earthwatch grant that enabled him and a fellow graduate student to do some unpopular research. The black sea turtle was on the brink of extinction, and addressing the decline required catching turtles to answer basic scientific questions. But the species was also at the center of political complexity, with turtle hunting by fishermen having just become criminalized throughout the turtle's range in Mexico.

Instead of insulating his science from this complexity, he engaged it. He said there was no "aha" moment, but that working with the community, "was always just kind of like, that's what you do."

> *… it made sense to work with fishermen, because we needed to catch turtles in the ocean. We needed a boat to do that. We needed nets to do that. We needed reliable information about where one might go to catch turtles, and I wanted to do that in as many locations as possible throughout northwestern Mexico. So having a boat, and learning*

through trial and error all of what one would need to learn, was not practical. Working with people who'd spent their lives on the water, not only on the water but catching turtles, because that's what people did – it seemed like the best way to go. So next thing you know, we're working with a lot of people who would be called turtle poachers, if turtle catching was illegal, and they'd be called turtle hunters if turtle catching was legal. That inflection happened in 1990, so many of them consider themselves turtle hunters, and this illegal business was just a recent inconvenience. So those relationships became critical too.

We hear J. recognize that partnerships with fishermen could enable not just access to boats, but also to their "reliable knowledge." At that point in time, fishermen were J. built relationships in both conventional and unconventional ways. He describes taking a road trip, early on in his work in Mexico, with the intention of visiting every sea turtle monitoring group on the entire Mexican coastline:

We ended up visiting 52 different research projects, and camping and helping and washing dishes, or working on the beach, just showing up as volunteers, and wide-eyed students. And that created a social network, and that social network still is very valuable. Part of what we do is helped by that ridiculous approach, that we still joke about with colleagues who are now in charge of agencies in Mexico. "Remember when you guys showed up in that truck, with your stuff on the roof, and your dog? That was pretty ballsy." And we're like, "yeah, I guess." But that shared story….

One role that has yet to be widely discussed in conservation, but which is emerging from network analysis studies in environmental management, is that of a network broker, or net-broker. Manring (2007) outlines that, "... net brokers manage the ecosystem management network and may also serve as facilitator, coordinator, moderator, talent scout, relationship promoter, trust bridge, caretaker, standard setter, disciplinarian, monitor, environmental scanner, policy entrepreneur, and steward."

She goes on to say that, "... a primary task of the net-broker function is to identify all stakeholders with vested interests and complementary resources." J., in his early days, managed to establish relationships with researchers, some who were destined for high-profile policy positions, and also with turtle hunters and fishing communities. J. notes the importance of the "shared story," of his coastal adventure in establishing those relationships. He also recognized the value of shared interests and shared curiosities as he expanded his work with fishermen in different communities:

> *... that initial conversation that goes something like, "I don't want turtles to go extinct, because for whatever reason I love them, as a scientist, or as an ecologist, and as a person, and you don't want turtles to go extinct because they represent your future and your kids future, and you like them, you like to eat them, but also you don't want them to go away, because it takes away one more possibility for the future, whether that's ecotourism, or sustainable use, or whatever it may be." And, it turns out, most of the people we worked with initially, also don't want – they don't want them to go extinct for, you know, just sort of, "that's just not right," kind of reasons. That would be bad for just more existential conversations about animals disappearing, not just not being good for us. Not being right.*

In the first sentence of this excerpt we can hear J. interconnect identities that scientists are generally expected to keep separate – specifically, his intimation that as a scientist (not just as an individual) he could *love* turtles. There are strong normative traditions, as well as explicit guidelines, that dictate beliefs and values must be divorced from scientific work in order for scientists to be open to discoveries that may contradict their personal views (e.g., AAAUP 1961). While it's not possible to see here if J. is able to compartmentalize in such a way, I question whether compartmentalization of this sort would help or hinder his ability to make and respond to discoveries. J.'s willingness to engage as an individual, and to not segment his emotional life and his scientific life, have arguably supported his effectiveness as a networker. To this end, J. describes doing some significant, albeit seemingly small things, that evidence thoughtful work on his part. For example, attentiveness to non-verbal communication cues, and awareness of politics and relationships.

> *... there's certainly no training in that, wasn't for me, I wasn't aware of anybody suggesting that you consider that reality when you're interacting with people on a conservation project. But all those little subtle things about people getting along or not getting along – you're creating a team to take care of sea turtles, and it's a big part of it, it turns out.*

Through his relationship with fishermen in communities throughout Baja, J. did create a team:

> *... in these conversations with mostly fishermen that I've been working with in all these different communities, they started saying, "well, what are you doing in Loreto?" or, "what are you doing in...?" Some curiosity about, "I know what we're doing here, and it's kind of fun and interesting, but who do you work with in these other places? And what do you do there?" And it turns out people were curious, and out of those conversations came the suggestion of – maybe not explicitly, but came*

> *together from those conversations – was the idea of getting all of the people we were working with in all these far-flung places together to talk. As simple as that. And so we decided on a place, decided to meet in Loreto – which was where we caught our first turtle, and logistically it's a very handy town. It has an airport, and it has small cheap hotels, and so that was it. We said, "ok, let's pick a date that doesn't interfere with whale watching season too much, and doesn't interfere with peak fishing season too much, and a location that's logistically handy, and let's let everybody know that we're going to get together."*

Although J.'s use of the word "we" makes it difficult to see his personal role in this particular work, he explained early on in his interview that, "I say 'we' a lot instead of 'I,' because it's always 'we,' it's fairly rare that it's you alone doing anything, so it's just more comfortable that way. ... I'm just used to saying 'we' instead of 'I,' maybe to a fault sometimes." Our understanding is that J., as a common point of contact among all of the different communities, had an important role to play in inspiring and convening this meeting, and he is cite by others as influential in that process (Schneller and Baum 2011). We could reasonably interpret his inclusive framing as an expression of humility, one critical attribute of interdependent work and research (Fortmann and Ballard 2011).

The meeting in Loreto launched a network called Grupo Tortuguero. Although the purpose of the *Grupo Tortuguero* network is described as turtle conservation (Delgado and Nichols 2004), J. talks about his early navigation of relationships in regards to his identity as a scientist. He shares, "It offers a bit of cover to say, 'hi, I'm a scientist.' Ok, that makes sense. 'Hi, I'm here to save turtles,' huh, I don't know. Then a wall goes up." Particularly when working as a cultural outsider, building relationships and networks demands sensitivity to shared interests.

Given how demanding it can be to build a network, one might ask how J. balances that with fulfilling the role of a science researcher. *Grupo Tortuguero* conducts regular turtle monitoring that supports a wide range of scientific research. And the group of fishermen, scientists, students, agency representatives, and others has continued to meet annually, to share research and monitoring results. J. remarked about a realization from a recent meeting:

> *... one of the observations that I made... was that by whatever measure you want to do it, sea turtle science per capita is probably the highest of any place in the world in Baja. We've really produced a massive amount of research on just about everything you could imagine studying about sea turtles, and peer-reviewed. It's in Masters and PhD theses, and it's presented at conferences around the world, and it's just a massive pile, and so the density of research in that region is enormous. And I'd say almost all of it, including the lab-based stuff, has required citizen science or participation of communities, community members and fishermen, in one way or another. So that's remarkable, by our strict measures of quality within academia, given those constraints and the peer-review process and so on, this model has produced some of the best sea turtle science in the world.*

Manring and Pearsall (2006) suggest that effective network brokers are those who serve as a steward to both the network and the fundamental purpose of that network – here, turtle conservation. J. acknowledges, as he goes on with this story, that academic research is not wholly sufficient to influence turtle conservation. He describes more nuanced ways that he sees the network supporting conservation action (see also Shirk Chapter 3). But he also describes ways in which he sees the process of research supporting a networking function, and how he makes a point of helping others to recognize the importance and relevance of interpersonal activities in parallel with scientific knowledge production:

> *You know, I talk to students now, Mexican students and American students, it's like, "a lot of this stuff that's really important is not necessarily going to be in your proposal." ...The lasting ... part of that work, has to do with the relationships that were built, the people who became interested who live in that town who are now still involved. Who tracked turtles all night by kayak, who hadn't done any kayaking before, and built camaraderie because they're up all night tracking turtles for weeks and weeks and months and months. And so that knowledge quest is still important, and it serves a whole bunch of other purposes, and it sort of makes – the pursuit of knowledge is a legitimate reason to be showing up, then people get it. And it's a starting point oftentimes for building the network, and for sharing other kinds of information.*

It is worth considering the difference between a network broker and the leader of a network. Manring and Pearsall (2006) suggest that networks are most effectively stewarded not by power but by individuals who are, "... proven and trusted as servants," committed more to stewarding the overall vision of the organization than to a leadership role. As one example of that, consider J.'s position on publishing scientific work:

> *... I'm not that interested in the academic game. The publish-or-perish thing is not appealing at all. So if publishing your research with a local newsletter helps solve the problem, then let's do that. If publishing it in a high-profile ecological journal helps, well, let's do that too. I look at the academic publication process as a tool, not as a goal or an end. So, a lot of times ... knowing that I wasn't really headed into a tenure-like life, if*

> *it's in academia, I'd say to my students or colleagues – I'd like to be last author, because I don't need to be first or second author."*

J.'s work for a coalition of non-profits that may allow him more freedom than many scientists to take such a position. Here, J. is showing us not only that he has the freedom to be magnanimous about authorship, but also his willingness to do so. He also is showing us his willingness to prioritize outcomes for individuals who are part of the network, as well as for the overall goal of the network itself.

Summary of key findings

Despite traditions that want to portray scientists as conducting clinically detached and technically minded research, these narratives begin to show us scientists who are productively stepping into additional, publicly-engaged roles. In these narratives, we see scientists engaging *with* the public. They are not just reporting and interpreting their science. They are engaging diverse values, listening and responding, and facilitating learning and action – integrated, relational work.

The relational roles these individuals fill – of activist, mediator, and network broker – are distinct from their roles conducting scientific research. And yet, far from being in conflict with their research, these narratives show us that such additional roles can be commensurate with – and in some cases essential to – their roles in the production of knowledge. This doesn't mean that taking on these additional roles has been easy. Candie, for one, seemed self-conscious in discussing her identity as an activist, and reluctant to identify as a research scientist. In other conversations, she calls out the lack of training or support for relational work, which we hear J. also mention.

It may be that citizen science, by bringing technical and social aspects of conservation into direct contact, offers a platform where different engagement strategies can be employed. For some, like Dan, citizen science may be a way of discovering the need to engage with the public as a means of facilitating action. For others, like Candie, it might provide an opportunity to meaningfully integrate a known interest and identity into their scientific work. This kind of work is dependent upon a scientist's ability to see and pursue new pathways – what they understand as possible and appropriate means for pursuing research and affecting conservation in their context (Shirk Chapter 3). It is, therefore, no coincidence that these stories each reflect different ways of engaging the interests, curiosities, and knowledges of the public. The interests of these scientists are diverse, and they as individuals are diverse in what they bring to the table in designing and/or supporting research partnerships with the public.

Although the roles they take on differ, I suggest that these individuals all arguably see and value building relationships as relevant to the work of conservation. These scientists show us that it is possible to make a space for more relational work while still conducting technical scientific research as part of a scientific research as a more multidimensional practice. These stories can help us consider how scientists, as human practitioners, might similarly draw upon a broader consideration of their humanity in their practice, to attend to the social dimensions that they see as ultimately enabling conservation.

DISCUSSION

Frank Fischer, in a book entitled *Citizens, Experts, and the Environment: The Politics of Local Knowledge* (2000), outlines the practices and problems of what he terms "technocratic environmentalism." These are problems that line up with many encountered in the field of conservation, particularly the need to critically consider ways that technical research and understandings can best address the needs of society. To these ends, Fisher concludes with a recommendation for what he calls participatory inquiry, a term which could encompass some models of citizen science and other forms of publicly engaged research.

Fischer calls for this endeavor to be taken on by experts: scientists and others trained in traditions of technical expertise. This call has strong and provocative implications for the roles of scientists who take up this charge, as it demands their attentiveness to the social and even political aspects of complex problems. Public engagement by scientists – particularly public engagement that goes beyond reporting and interpreting results – is not an easy or insignificant undertaking. In the Pacific Northwest investigation of attitudes about scientists' roles, Steel et al. (2004) and Lach et al. (2003) revealed significant institutional pressure on scientists to conform to standard, "separatist" roles (such as reporting), or risk jeopardizing their professional credibility and personal authority.

Fischer's vision for participatory inquiry thus raises pressing questions about whether scientists can do engaged work without threatening the promise of science for providing credible, reliable knowledge. It can also raise questions among the public about the agenda technical experts might have for informing decisions and guiding actions. Given social and disciplinary traditions that expect researchers to be detached from public interests, are there ways that a scientist can be both a credible, expert researcher and an effective, trustworthy facilitator of public learning?

One way that some scientists working with citizen science might navigate such threats is to avoid personally taking on publicly engaged roles, instead collaborating with others who can cover the necessary public-facing work. This lines up with the role of an "impartial expert" as described by Steel et al. (2004; Table 5), as well as a common role for academics at land grant institutions as described by Scott Peters (2010). Peters utilizes narrative research to reveal, among other things, ways that individuals in Extension are seeing and pursuing different possibilities for including more engaged work. The narratives shared in this chapter similarly allow us to see ways in which a few scientists are taking up additional and unexpected roles in relationship to the public through citizen science.

While there are many diverse roles we can see across the full set of narratives (Appendix C), the three roles that we review in this chapter are particularly unexpected of scientists. We see Candie, as an activist/facilitator, reconfiguring her citizen science project to a bottom-up model that lets citizens set the research agenda to inform change. Dan shows us his willingness to engage conflict, mediating disputes by inviting the public to identify and monitor issues of concern. And J. reveals how his attentiveness to interpersonal and interagency relationships helped broker a network among and between unlikely partners to facilitate sea turtle research and conservation.

The social and relationship aspects of these roles can certainly complicate the project of producing knowledge, at least in the ways often expected by scientific peers and for technical purposes. Candie, for one, talks about her difficult but intentional choice to pursue research more aligned with public interests and social action than with publication. But with this focus, and through her role as an activist/facilitator, Candie's work still frames technical, rigorous research as an essential tool to inform social action.

In exploring how professionals work effectively across boundaries to address complex problems, Edwards (2010) emphasizes that rigorous disciplinary knowledge is an essential component of relational work. Rather than sacrificing research rigor for public engagement, effective relational work serves to negotiate an appropriate place for disciplinary research and knowledge in regards to other relevant understandings. Edwards talks about relational work in terms of expert, disciplinary boundaries, but I suggest that this concept is also relevant across knowledge boundaries between technical expertise and local or lay understandings of complex problems. To make a space for such work, Edwards describes one initiative that created:

> *… neutral spaces where the values and professional priorities of each practitioner were respected, where information about resources could be shared and where trust could be built. They were places where local expertise could be made explicit so that it might be drawn on later.*

When we see Candie facilitating communities in developing research questions, or J. brokering a monitoring network across local communities, researchers, and politicians, I suggest there is an opportunity to consider how public engagement may enhance the trust necessary to ensure their credibility in the public sphere.

Here it is important to distinguish between the perceived credibility of an individual scientist and the credibility of scientific research findings. Work by Lach et al. (2003) reveals that LTER scientists in the Pacific Northwest perceived their peers' credibility – and thus their authority – as related to scientific methods and publications. However, managers and the public tended to gauge scientists' credibility as a factor of the usability of their research and the individual scientist's ability to communicate that research to non-scientists. Ultimately, Lach et al. suggest that both elements are factors in determining the ultimate use of research for decision-making.

The latter, regarding the relevance of research findings to the public and the fairness of the process by which the research was conducted, can be difficult to address without engaging with the public. Helga Nowotny (2003) invites us to consider whether the credibility of individual scientists may in fact be jeopardized if they do *not* engage with the public in the face of complex problems. If scientists are hesitant to engage with the public for fear of damaging their credibility, it is important to recognize that credibility has as much to do with relationships and trust as it does with substance.

From what we can see in the narratives shared here, garnering public trust and interpersonal credibility can benefit to a certain degree from technique and methods. Candie draws upon lessons from participatory research, sharing that, "... the whole thing about building community capacity, and allowing communities to set the agenda and working with a bottom-up model, requires that you be responsive. It's our philosophy, it's very intentional." But engendering public trust can also depend on smaller details, such as J. paying attention to, "... all those little subtle things about people getting along or not getting along," in order to build a network for turtle research. Rather than public engagement jeopardizing scientists' reputations, this research helps reveal both procedural and personal ways that scientists might lay the groundwork for establishing public credibility, to effectively and sensitively engage around usable information.

I suggest that the narrative experts from Candie, Dan, and J. invite consideration as to whether citizen science provides a vehicle through which they can productively take up multiple roles to address complex problems. Citizen science is situated at the boundary between scientific knowledge and public knowledge of others, with a focus on the production of new scientific insights. Shirk et al. (2012; Chapter 2) suggest that effectively achieving citizen science project goals, including goals for research, depends upon attending to the *quality* of participation for volunteers, building relationships to understand and work with the interests of public participants. Given this, I suggest a need to expand the suite of roles that are seen as appropriate for scientists, and help us move beyond our expectation that scientists should, or even can, be detached and autonomous actors when working in the interest of complex social-technical problems.

CONCLUSION

Given that conservation is a human and social endeavor, society (and particularly scientific/conservation institutions) may expect too much from science and its technical ability to affect conservation outcomes. I argue that a similar mistake may be to expect too little of scientists as individuals, by not trusting or allowing them to engage beyond the technical. Recognizing, appreciating, and allowing the interpersonal and human elements, complexities and all, that individual scientists can bring to the conservation equation can be challenging. The narratives shared here let us see an expanded set of possibilities for scientists interested in pursuing more engaged work and the fertile ground citizen science offers to pursue this. I suggest that there is also a more general a need for many players in the conservation landscape to appreciate the multi-dimensional roles and identities that scientists can productively fill to engage with the public.

These narrative excerpts also allow us to see and consider the challenges, difficulties, and tensions that can be encountered when taking on engaged, relational work. Scientists can have reasonable concerns about engaging with the public, particularly through citizen science where the research outcomes are at stake. It is helpful to see ways that different individuals handle worries and concerns about credibility and validity, and how they navigate those concerns to make publicly engaged work possible and meaningful. and can give us the opportunity to further try on and try out new roles in ways that are sensitive to those challenges.

Our findings suggest that scientists, when given the opportunity, can creatively and productively engage the public and, more generally, the relational aspects of complex social-scientific problems. I suggest there is call to further explore the lessons that can be drawn from understandings of relational work and expertise, as well as the opportunities that these insights might offer for guiding multidimensional, publicly engaged roles for scientists to address complex problems such as conservation.

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CHAPTER 5

"MAKE SCIENCE RELEVANT." CITIZEN SCIENCE AND THE MULTIPLE DIMENSIONS OF SCIENTIFIC PRACTICE

INTRODUCTION

This is a critical time in the growth of the field of citizen science. As the field is formalizing, one of the biggest challenges is defining boundaries of appropriate practice. Some talk about citizen science as a technical, methodological approach to research, safeguarding the scientific aspect of these partnerships by emphasizing rigor and quality of research products (e.g., Dickinson et al. 2010). Others have used the term citizen science as a call for public engagement, equity, and justice in the discourse of science and in setting the research agenda (e.g., Irwin 1994). These perspectives seem difficult to reconcile, as they prioritize different approaches to collaboration and different outcomes of the research partnership (Silka 2013).

The conversation about what "counts" as citizen science has a particular relevance for participating scientists who have much professionally at stake. Many conversations in the scientific literature about citizen science are couched, very literally, in terms of "trade-offs," implying distinct tensions between the potential value of citizen science for science, education, policy, and other aims (e.g., Tulloch et al. 2013, Parsons et al. 2011, Lukanenko et al. 2011). The narratives and discourse we encounter in our professional communities, such as peer-reviewed literature, significantly frame what is considered legitimate work (Kuhn 1962, Harding 2000). One consequence, recently described by Provençal (2011), can be academics who feel forced to choose between demonstrating research success within their discipline and demonstrating relevance of their research to other arenas.

Negotiations and choices – among interests and towards outcomes – are unavoidable in planning and managing a citizen science project, particularly in collaborations that engage complex social-technical issues such as conservation or public health. Thought leaders in these fields, however, are calling for individuals and institutions to confront previously understood constraints of scientific practice in order to make science a more effective and relevant part of the conversation (e.g., Silka 2013, Palmer 2012). We suggest that rather than thinking of tensions between social and technical aims in terms of "trade-offs," an alternative and potentially more productive way of considering negotiations and choices towards project outcomes is in terms of ***synergies***. The ongoing, innovative work of scientists – as both influential participants and instrumental designers in projects – is beginning to show us that much more multidimensional work is possible through citizen science partnerships than what current literature and associated norms of practice easily allow us to consider.

WHAT *SEEMS* POSSIBLE?

Scientists in many fields are beginning to imagine the scientific advancements that can be achieved through partnerships with the public. Take, for example, an excerpt from a 2013 Harvard Medical School News article entitled, "Solving the Big-Data Bottleneck," describing a successful crowd-sourced solution to an immunology problem (Cameron 2013, see also Lakhani et al. 2013):

> *"This study makes us think about how greater efficiencies in academic research can be obtained," said Karim Lakhani, associate professor in the Technology and Operations Management Unit at Harvard Business School. "In a traditional setting, a life scientist who needs large volumes of data analyzed will hire a postdoc to create a solution, and it could take well over a year. We're showing that in certain instances, existing platforms and communities might solve these problems better, cheaper and faster."*
>
> *…. According to Lakhani, it is not only the world of basic biomedical research that can benefit from this project, but any organization that is facing significant data analytics and computational challenges. "Our research with Harvard Catalyst and the NASA Tournament Lab initiative points to the applicability of deploying crowds as an innovation partner for extraordinarily difficult challenges where there are significant personnel and paradigmatic bottlenecks," he said. "This paper highlights the use of an alternative organizational form that is cost effective and productive. Many more organizations should also be considering how to effectively use crowds for problem solving."*

Given the skepticism about citizen science, such positive statements from highly respected institutions such as Harvard Medical School, can go a long way towards influencing more positive considerations of public participation in scientific research as a valid scientific endeavor. We are beginning to see, despite skepticism, that meaningful scientific advances and discoveries have been enabled by new approaches to research that open the process to public contributors and collaborators (see, for example, Hand 2010, Dickinson et al. 2010). The field of citizen science is advancing beyond a period of needing to defend its credibility and utility as a research approach.

However, taken alone (and arguably out of context), statements such as this can reinforce a narrow notion of the kind of work that is appropriate, possible, meaningful, and even necessary when it comes to opening the research process to engage the public. This excerpt illustrates an instrumental stance towards the *use* of crowds, and constrains the conversation to a focus on the technical and utilitarian aspects of such an endeavor. It also obscures the investment and extent of work that can be necessary to facilitate such research partnerships.

As I have learned through my research, there is a wide range of other ways that scientists can and do talk about citizen science, in terms of what it is, what it's good for, and how they can be involved. Scientists' narratives of practice show us that some scientists have much broader interests in social as well as technical outcomes, and demonstrate the relevance of scientists taking on roles that engage public interests and values. From these narratives we can start to appreciate how perspectives about citizen science as primarily instrumental and technical work can result in limiting what is seen as possible, as well as what are considered as meaningful and appropriate endeavors for scientists.

Narratives about appropriate and possible work

For better or for worse, the narratives that scientists encounter regarding what are professionally appropriate and possible citizen science pursuits are primarily found in peer reviewed scientific journals. To date, journal articles have tended to offer one of three sensible – but potentially conflicting and limited – narratives about appropriate rationales and strategies for engaging in citizen science: that it is a means to new science;

an opportunity for education and outreach; or that it demands a trade-off between science and social aims. These narratives largely reflect, rather than challenge, traditional expectations of appropriate scientific work. As such, one could argue that there are productive and helpful elements of these narratives, as they can allow researchers to see a pathway into citizen science that fits within conventional practice and acceptable outcomes.

I propose, however, that encountering any single narrative about citizen science in what is a widely dispersed and difficult to navigate body of literature can portray a limited vision of appropriate and possible citizen science work. Following that, the assumptions these narratives convey may influence choices by scientists as to how and why they might become involved in, or critique, such activities. Here we share some of what the literature offers in terms of the kinds of citizen science work that is possible and even appropriate work for scientists, as related to the kinds of outcomes that individual scientists might strive to achieve.

A means to new science

Citizen science could be understood as primarily a means to achieving scientific outcomes by accessing otherwise unavailable data to advance scientific research and/or science-based management. A move to demonstrate the scientific merit of citizen science has brought attention to the feasibility of publishing work in peer-reviewed journals (e.g., Dickinson et al. 2010, Bhattacharjee 2005). Certain timely areas of research, such as studies of the impacts of global climate change, have a requisite need for large-scale and/or long-term datasets uniquely available through contributions of amateur experts (e.g., Devictor et al. 2012, Hurlbert and Liang 2012, Primack and Miller-Rushing 2011), and new technologies and statistical techniques position work with these datasets as cutting-edge (e.g., Hochachka et al. 2012).

In these literature contexts, what is reasonably emphasized and evaluated is research effectiveness and efficiency. Numerous publications solely assess the quality of data and whether citizen science can produce "real" science (e.g., Bhattacharjee 2005, Boakes 2010, Kremen 2011). Much of this work speaks of "*using* citizen science" for research, and some of the papers focus on the data to the complete exclusion of the human individuals or experiences involved in producing the research (Cooper et al. submitted). From this literature, an interested scientist might assume that he/she could become involved in citizen science to pursue primarily scientific activities and interests, and maintain commitments principally to scientific outcomes, without a need to engage with the public or public concerns. While this is possible, my research suggests that effective design of citizen science projects demands attention to public as well as scientific interests (Shirk et al. 2012; Chapter 2).

A means of education/outreach

Citizen science could alternatively be understood primarily as a means of supporting social/civic goals or outcomes such as education. Although such a vision may be less explicit in the literature, several high-profile "call to action" articles mention citizen science as an outlet for scientists considering public engagement and education (e.g., Jordan et al. 2009, Groffman et al. 2010, Bickford et al. 2012). I distinguish this narrative thread about citizen science from other, more robust, considerations of educational outcomes because none of these pieces mentions the research merits, or even intentions, of citizen science.

In some contexts, outcomes such as education and outreach to stakeholders have themselves begun to be part of professional expectations (e.g., Nadkarni and Stasch 2013). However, a significant time investment may be necessary to effectively design and administer a citizen science project, which should not be underestimated as an "easy" means of satisfying education or outreach mandates (see, for example, Bonney et al. 2009*a*, 2009*b*). Similarly, a significant motivation for participants in some projects is their contribution to authentic scientific research and discovery (e.g., Raddick 2010, Lawrence 2006).

A trade-off between science and social aims

It is likely that the vast majority of participating scientists recognize that citizen science is necessarily a combination of both research and education/engagement. A recent special issue of the journal *Frontiers in Ecology and the Environment* gives equal footing to science and education as reasons and options for researchers to consider citizen science (Henderson 2012). Publications in other prominent science journals promote citizen science as an opportunity to simultaneously achieve research and education, and/or research and conservation action (e.g., Bonney et al. 2009*a*, Silvertown 2009, Cohn 2008, Cooper et al 2007, Greenwood 2007, Danielsen et al. 2005).

Coming to citizen science with these works in mind, a scientist could assume that citizen science will, of its own multi-faceted nature, achieve outcomes for science as well as education or action. This carries the risk of underestimating the deliberate work necessary to achieve *desired* outcomes, particularly multiple kinds of outcomes (Shirk et al. 2012). Much of the literature about citizen science also represents project design as balancing competing goals for science and social outcomes. Choices are positioned as "trade-offs" and spoken of in terms of compromises (Zoellick et al. 2012, Dickinson and Bonney 2012, Krasny and Bonney 2005). Thinking in such terms, participating scientists might compromise their goals for science, education, and/or conservation, anticipating tensions rather than synergies in their work with the public.

Limitations of narratives in the literature

None of these narratives about citizen science is, in and unto itself, incorrect. However, narratives about trade-offs, or even about singular disciplinary outcomes, can reinforce limited understandings of what is possible through citizen science and perpetuate constraining institutional expectations of what constitutes appropriate work for scientists. Limited narratives can also obscure the work that is necessary (e.g., Bonney et al. 2009) and the more synergistic outcomes that are possible (e.g., Berkowitz et al. 1996, Shirk et al. 2012).

My research suggests that these limited narratives also have not yet captured the significance of the human choices and values that come into play when engaging multiple parties and multiple interests in research collaborations. I suggest that it is important to not overlook (and thereby effectively diminish and undervalue) the experience and the meaning of this work to the individual scientists who are deeply invested in citizen science (Peters and Franz 2012), not to mention their innovation, commitment, and judgment (Shirk Chapters 3 and 4).

WHAT *IS* POSSIBLE?

Looking across dispersed bodies of literature, it is possible to see that citizen science projects are in fact striving for, and can successfully achieve, multiple outcomes. In conservation, a survey of projects revealed desired outcomes in three categories, which Bonney and Dickinson articulate as outcomes for research, for education, and for stewardship (2012). Using related categories of science, individuals, and social-ecological systems, Shirk et al. (2012) offer a framework to guide the deliberate design of a given PPSR project towards naming and achieving multiple outcomes. The framework explicitly draws attention to the relationship between different interests that intersect in the design and management of citizen science initiatives.

An argument can be made that it is this intersection between public and scientific interests that offers such important opportunities for conservation, or for addressing social-technical issues in other fields. But if we presume that scientists, as influential players, are afforded only a limited understanding of what is appropriate and possible for them to pursue in scientific careers, how might integrated outcomes be achieved?

Emerging role models

When we actually ask scientists what they are doing in citizen science, and what they find to be meaningful parts of that work, we hear surprising things. We hear stories that evidence interests and roles that are far more complex and multifaceted than the literature, and unspoken institutional constraints, might suggest are appropriate. Detailed, compelling stories, available online, of nine scientists who have demonstrated ongoing commitments to citizen science are allowing us to see new possibilities for publicly engaged scientific work. Through in-depth interviews, individual scientists articulated diverse and nuanced theories about how they can bring their science to bear in complex social settings (Shirk Chapter 3). They describe stepping into roles in relationship to the public – roles that are generally unexpected of scientists – with an eye towards achieving conservation outcomes (Shirk Chapter 4).

A few examples include:

- Terry Root, a professor at Stanford University and a Nobel Laureate for her work with the IPCC, early in her career demonstrated that volunteer-generated datasets from Audubon's Christmas Bird Count can be used for rigorous scientific studies (Root 1988*a*, 1988*b*). She articulates interests in addressing the issue of climate change, not just through the science she produces but also through the experiences people can have by participating in these projects (which she herself experienced). She now mentors students not just in using these datasets, but also in designing volunteer experiences to more effectively engage a new generation (e.g., iNaturalist).

- Dan Canfield, Professor of Limnology at the University of Florida, has research access to lakes across the state through Florida LAKEWATCH. He started the project after landowners convinced him they could collect data that would allow them to address a water quality issue. In addition to decades of research, both primary and applied (e.g., Canfield et al. 1983, Canfield and Hoyer 1988), Dan has also developed a model to mediate science and public opinion in highly controversial contexts (Canfield and Canfield 1994).

- Caren Cooper, an ecologist at the Cornell Lab of Ornithology, leverages the Lab's NestWatch data to conduct original research into how latitudinal variations in photoperiod affect nesting birds (Cooper et al. 2005). Unsatisfied with the impact of this primary research on conservation, Caren now also pursues conservation-minded questions through research into the human dimensions of citizen science (Cooper 2012).

- Karen Oberhauser, an entomologist at the University of Minnesota, started the Monarch Larvae Monitoring Project after years of engaging teachers nationwide in monarch education programs. She tapped into and expanded that network to solicit data on larval mortality and monarch distribution. Karen supports youth in asking their own scientific questions of these data (Kountoupes and Oberhauser 2008). By also listening to questions from volunteers, she has been able to collaboratively pursue new research (e.g., Oberhauser et al. 2007).

Here, we see scientists doing *science*. But we can also see them each doing something more. We can see them being attentive to seemingly small but significant possibilities, in ways that have enabled them to pursue additional goals that are commensurate with, not in opposition to, their science (Shirk Chapter 3). We can also see them grappling with tensions as they consider and pursue those possibilities (Shirk Chapter 4).

These individuals do speak frankly about difficult choices, and even trade-offs, they have had to make in pursuing research through citizen science. Unlike what might be understood from peer-reviewed scientific literature, Rather, their choices are largely related to when and how to emphasize and prioritize different aspects of integrated work. Terry, for example, speaks about her strength as related to research, as well as her choice to advance social aspects by mentoring students who are more inclined to work on public engagement.

In seeing what is possible, I don't intend to gloss over the nuances and complexities of any citizen science work. These narratives do also reveal difficult choices, seeming contradictions, and even regrets. Such realizations should not be considered discouraging, but rather realistic aspects of citizen science and of conservation as human endeavors. These aspects of practice are also incredibly informative, as we can learn both from what worked and from what didn't work (Peters 2010, p. 66). In addition to possibilities, these narratives can help us identify where the difficulties actually are instead of where we assume they might be. With these insights we can begin to acknowledge and better understand that this work is both complex and achievable.

IMPLICATIONS

Much of what we heard from scientists in this research doesn't seem, on the surface, to call into question conventional scientific practice. Rather, we suggest that they are doing big things in seemingly small ways. If, as philosopher of science Sandra Harding (2000) suggests, "... scientific practices ... always represent political priorities, meanings, and ideals," these practices are showing us ideals, meanings, and priorities that haven't recently been attributed to or expected from scientists. By seeing the work that these individual scientists take upon themselves and enable of others, these stories are providing us opportunities to think more broadly about citizen science and the endeavor of science itself.

For individual scientists

If we can acknowledge the possibility for citizen science to advance multifaceted goals, and can see roles for scientists to engage in this complex work, what expectations does that set up for individual scientists? Does the prospect of taking on citizen science require of scientists, as Cash (2003) describes in the context of engaged research for sustainability, “a truly radical contract for scientific careers?”

Not all scientists are, or arguably should be, expected to tackle multiple dimensions of citizen science work. While some scientists are solely responsible for all project duties, many work with staff, or in collaboration with other institutions that manage different aspects of project work. There is great value in separate strengths of practice, but there is also a parallel need to acknowledge that other aspects are possible and appropriate. Citizen science can and must attract scientists who, for example, focus groundbreaking analytic skills on the interpretation of messy datasets. But my research suggests a need to recognize that this work is connected to the possibility of supporting and achieving other, complementary outcomes that scientists can pursue in addition to their research. At the outset of a new field of practice for citizen science, we have the opportunity to establish a community of scientists who are appreciative of each other’s work and respective efforts towards diverse outcomes. This requires being attentive to possibilities, and understanding those possibilities as legitimate, and need not require doing anything radically different.

It is fair to ask whether it has taken the work of extraordinary individuals to pioneer these approaches to science and to persevere with goals that *they* found meaningful and rewarding regardless of institutional expectations that may have not easily permitted their visions. As more and more researchers are now getting involved in citizen science and PPSR, can their work in this field of practice be supported and sustained? It is possible that the examples of these individuals can serve to demonstrate how thinking and acting differently can offer new ways of doing work, as well as what citizen science might uniquely offer as one means for pursuing both research and socially-minded interests such as conservation. Their perseverance and success may open some new avenues in their professional spheres that can make citizen science seem more feasible, more appealing, and even more accepted. Their narratives can help pave the way, providing models for others to follow in their footsteps. They can also offer a starting point for informing theory and developing infrastructure to support future work.

Part of this requires giving scientists the tools to be able to talk about this kind of work in new ways. "Citizen science" has often been presumed to mean one thing (albeit different things to different people). There is the risk of becoming trapped in language as well as in traditions (Provençal 2011). We have an opportunity, at the naissance of this field, to intentionally begin to think and talk differently about what is possible for scientists and others engaged in this multidimensional work.

For citizen science as a field of practice

As a field of practice is being established, this brings us back to the question of what "counts" as citizen science. Can seeing a diverse array of meaningful work help us cast a definition for the field that transcends earlier definitions and typologies offered by Irwin, Bonney, and others? How might we begin to draw an inclusive boundary around this practice that includes attention to social and civic dimensions without either diminishing the scientific core of citizen science work or prioritizing scientific outcomes at the expense of other possibilities?

The narratives of individual scientists engaged in this work are suggesting that many may already be operating within a broader definition of citizen science. We can honor this by making a space to acknowledge that scientific work – and that citizen science work – is more complex, nuanced, and richer than we sometimes presume, and that the synergies can enhance, rather than detract from, the impact of the science itself. As this field grows, it is important to consider the critical elements of possible and appropriate work for scientists in citizen science as including both the essential nature of the research and the meaningful work of engaging with the public.

At the same time, we should consider defining a space that recognizes synergies *across,* as well as within, projects. This field is comprised not of a monoculture of scientists or projects, but rather offers an 'ecology' of project types that fill different niches, meet different needs, and demonstrate different possibilities across a diverse field. Recognizing multifaceted possibilities can help us establish a space that permits contradictions and tensions in the way that individual scientists and individual projects conduct and speak about their work, both in the goals and ideals they strive for and the practices and philosophies they employ towards achieving them. By drawing boundaries in an instructive, inclusive way, this field of practice can provide a space for individuals and projects to learn from one another's distinct approaches and contributions.

CONCLUSION

In contrast to the opening excerpt about the Big Data Bottleneck, consider the following thoughts shared by Julia Parrish, Associate Dean of the College of the Environment at the University of Washington and founder of the Coastal Observation and Seabird Survey Team (COASST). She reflects that:

> *... science isn't very relevant to society. And I think that one of the reasons is because we insulate ourselves so well from society by convincing ourselves that without a higher degree, you can't really talk to people who are as smart as we are. That's a really, really dangerous thing.*
>
> *COASST made me open my eyes and see that reality, and decide that I could be part of the scientific community, but also be part of a larger community, and be just as comfortable talking to somebody about how to identify some rare bird or what happened to it, or the natural history of the conservation of it, as I was having a conversation about what else they found on the beach or what their grandkids are doing, or what car they bought, or any of the myriad of normal things that normal people talk about. And all of that made me realize that if we really want to see science continue through this century as a set of independent inquiries, which is kind of what science is, then we had to involve many, many more people. And not by training them to be exact versions of us, but by giving them reasons to see why science is relevant in their lives and their communities. COASST does that in a really small way, we're one very, very small part of what I hope will become a very large movement to make science relevant.*

By sharing such perspectives, Julia and other scientists engaged in citizen science are opening pathways. They are helping us see and begin to understand the value of the civic dimensions of scientists' work not just for their own science, or for citizen science, but for the endeavor of science itself as a human practice. In small ways, with large consequences, they are starting to challenge expectations, push boundaries, and expand our thinking, to encourage diversity, accept tensions, and welcome new and unexpected ideas that can help us see and achieve the broadest range of possibilities. As we expand the narratives about what it is possible for scientists to do through citizen science, this helps us begin to open a research path and agenda, not complete one.

These stories and insights can also help us set an agenda for the growing field, and for the multiple disciplines in which scientists engage in citizen science. Such an agenda encompasses both recommendations for field of practice and additional research questions that can expand our understandings of theories informing this field.

Recommendations for the field of practice

Some of the challenges we confronted regarding scientists' work in citizen science stem from the constraints of institutional and cultural norms. The recent establishment of a Citizen Science Association (CSA) can serve an influential role in helping the field to establish and productively reinforce new norms that make a space for the broader and more multi-dimensional practices revealed by my research.

Very practically, the CSA can provide tools and trainings that invite, rather than discourage, scientists to intentionally consider both the social and the technical aspects of their work. It can help develop and provide tools to enable and support accountability, and establish reward systems to recognize contributions (e.g., Weiss 1995) that may otherwise be overlooked and underappreciated within more traditional research spheres.

The CSA can also begin to develop a richer and more inclusive narrative about appropriate and productive work of scientists. At the most basic level, establishing a new peer community can help members recognize that they are not alone in challenging the norms of their more traditional scientific disciplines. More intentionally, the CSA has the opportunity to intentionally seek out and showcase work by scientists that pushes boundaries. Venues for this could include an association website or space in the journal that is planned for the field. When shared both within and beyond the CSA community, these pieces can help to reframe and broaden the identities and expectations of scientific experts. Collectively, these actions can serve to, as Sullivan (1995) phrases it, "articulate a public philosophy" for the field of citizen science.

Expanding theoretical understandings through further research

Among the many compelling questions that emerge from revealing the multidimensional work of scientists in citizen science is the potential to address implications for knowledge production. Philosopher of science Helen Longino (1990) notes that, "... scientific knowledge... rests on a bed of presuppositions about what questions are important, what sorts of connections are meaningful... which causal relations are worth investigating or establishing...." This research has brought attention to ways experts can express and pursue social as well as technical goals. It has also hinted at instances not just of attempts at problem solving, but at what Schön (1983) calls "problem setting," the collaborative process of identifying what issues to address and how to address them. Through scientists' stories we see work that invites consideration of shared social and scientific purposes, and relationships that can serve to balance rigor and relevance of research. Together, these attributes suggest the enticing possibility that engaged and relational work by scientists might enable us to fundamentally change not just the kind of research that is possible, but also the very nature of the knowledge that results.

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APPENDIX A

TABLE OF INTERVIEWEES

Nine scientists interviewed in this research, and the projects and institutions they represent. Details listed here reflect their positions at the time of interview.

Scientist	**Project(s)**	**Professional setting**
Dan Canfield	Florida LAKEWATCH	University of Florida
Caren Cooper	Project FeederWatch; Project NestWatch; My Yard Counts	Cornell Lab of Ornithology
Matthew Godfrey	North Carolina Sea Turtle Project	North Carolina Wildlife Resources Commission
Bill McShea	Earthwatch (various); Appalachian Trail camera trapping; butterfly surveys; warm season grass project	Smithsonian Conservation Biology Institute
Wallace "J." Nichols	Earthwatch; Grupo Tortuguero	California Academy of Sciences; coalition of non-profits
Karen Oberhauser	Monarch Larva Monitoring Program, Monarchs in the Classroom, Driven to Discover	University of Minnesota
Julia Parrish	COASST (Coastal Observation and Seabird Survey Team)	University of Washington
Terry Root	Christmas Bird Count; Breeding Bird Survey	Stanford University
Candie Wilderman	ALLARM (Alliance for Aquatic Resource Monitoring)	Dickinson College

APPENDIX B

INTERVIEW SCRIPT

Interview script

This script served as the basis for the first of several interviews, and informed subsequent interviews. This script was for an interview estimated to last no more than 1.5hrs (with 2-3 subsequent conversations to follow at no more than 45min). Interviews were semi-structured. The script below was used as a starting point rather than an outline, with initial queries and prompts encouraging extensive answers. Each resulting narrative is particular to a person and project, depending upon the topics that emerged from initial questions and the flow of the conversation. Prompts were employed as necessary and relevant. Questions in subsequent interviews will explore themes unaddressed, or incompletely addressed, in the first interview, and will be informed by trends revealed through ongoing analysis of interview data.

Importantly, this script represents my thinking and assumptions going into the interviews. The focal questions for the chapters in this dissertation reflect analyses that are more pertinent to the resulting narratives.

Thank you for taking the time to talk with me. In short, I am interested in learning more about the type of work you have been involved in, what difficult choices you have needed to make, and how and why you continue to be involved. Elaborating on your demonstrated successes with your project(s) can help others better understand both what is possible to achieve and the work it takes to get there.

Opening Question	***Topic****
First, how would you describe your citizen science project and your part in it to someone on the street?	*BB, PM*

Prompts:	***Listen for:***
What is your role?	*Research question.*
Tell me about who else is involved.	*Project goals.*
	Partners, participants, their respective roles.

***Topics**

KO - *Knowledge outcomes*	***GS -*** *What counts as good science*
SI - *Sustained/future involvement*	***PM -*** *Particular/perceived model*
PE - *What is appropriate public engagement*	***BB -*** *Basic background*

More Specific Questions

Tell me about how you became involved in this [type of] project. *GS, PE, PM*

Prompts:	***Listen for:***
At what point in the project? *At whose invitation?* *What did you first think?* *And then what?* *What changed your mind?* *How did you deal with that?*	*Why and how s/he became interested in the project.* *Events/ideas that prompted change.* *Tensions/dilemmas (e.g., science, education, conservation).*

Question

Can you tell me more about the research work of this project (and how it may have evolved)? *GS, PM*

Prompts:	***Listen for:***
What inspired this approach? *How has it come to be that way?* *What happened then?* *How did things progress?* *How was that negotiated?* *What did you do next?*	*The research question/focus and significance.* *How this question/focus was inspired.* *Events/ideas that prompted change.* *Tensions/dilemmas (e.g., science, education, conservation).* *Who had input.*

Question

And what has been learned through this project? (intentionally not prompting re: science, education, logistics) *KO, GS, PE*

Prompts:	***Listen for:***
What have you *learned?* *How did that fit the research?* *How did that come about?* *Why does that matter?*	*Different knowledge outcomes (sci/ed/process).* *Particular interests/needs.* *Tensions/dilemmas.*

Question

How has your work evolved by participation in this project? *GS, KO, PM*

Prompts:	*Listen for:*
What have you done that's unexpected/new?	*Tensions/dilemmas.*
What did you first think?	*Particular interests/needs.*
And then what?	*Changing interests/needs.*
What changed your mind?	*New opportunities.*
How did you deal with that?	

Question

Can you tell me about your next steps for this work? *SI, KO, GS*

Prompts:	*Listen for:*
Why do that?	*Continued involvement.*
And then what?	*Reasons for staying involved, valued attributes.*
What has inspired that track?	*Changes in perceptions.*
	Tensions/dilemmas.

APPENDIX C

PRACTITIONER PROFILES

OVERVIEW

Practitioner profiles are first-person narratives, here of scientists engaged in citizen science related to conservation research. Profiles should be read and understood as spoken texts, not written documents, reflecting the personal, informal, and idiosyncratic nature of conversation. As records of spoken conversations, these documents represent interpretations of individuals' circumstances and understandings at a point in time. These profiles invite multiple interpretations, beyond what are offered in the chapters of this dissertation. They also call for sensitivity to and respect for the time and trust of these individuals, who willingly and generously shared their stories, theories, insights, experiences, and perspectives.

Dan Canfield

University of Florida – LAKEWATCH

Leading the charge

I spoke with Dan Canfield in February of 2011, and again in January of 2012, two of the most entertaining and surprising conversations of this research. Dan is a straight-shooter, comparing himself to General Patton in one moment and President Eisenhower the next. Both historic figures were, of course, known for being forthright, albeit in very different ways. The "Patton" in Dan Canfield doesn't flinch at tackling difficult problems or confronting controversial issues. Dan's "Eisenhower" worked to develop a mechanism for engaging the public and scientists in addressing conflict: Together for Environmental Assessment and Management. The TEAM Approach involves some environmental monitoring, but Dan's primary PPSR work is through Florida LAKEWATCH, which he started over 20 years ago and through which work he has published at least that number of papers.

My training is in the field of limnology, with a specialty in the management of aquatic systems. While some people call me a researcher, quote-unquote, I oftentimes am using old ideas and putting new numbers to them, to justify what of the old ideas are either correct or incorrect. And so when I deal with the citizens' groups, they like me a lot of times because I'm an applied person, that's there trying to solve a problem. In other words, when a problem arises, what are all the possibilities vs. probabilities. And I work towards probabilities first, but a lot of my colleagues seem to like the possibilities. I call myself an applied manager of aquatic systems.

I graduated with my PhD from Iowa State University, and I came down here to work on aquatic weed problems, researching aquatic weed problems and how to control aquatic weeds. I got here in '79, and in '79 I did a survey of lakes all across the state. By the mid-1980s, there was an economic downturn going on, and the public people who lived along lakes wanted help on their lakes, because the environmental stuff, environmental awareness was really beginning to increase. I was sitting in my office and some citizens from Santa Fe Lakes came in and said they wanted help on their lakes, and I told them I didn't have staff or money to do it. They said, "we'll do the work, you just tell us what to do." And I thought about it for a little bit, and I got thinking, "well, I get graduate students right out of college who know virtually nothing, and here are CEOs and presidents of companies asking me to do this, and they said they can learn." So I said, "well, I guess they can learn." So I started training them to do the simple stuff, which is to collect surface water samples for the water quality, and that was the start of the LAKEWATCH program. And by 1990, the Florida legislature picked up on all of this, and realized we were sort of – I'll call ourselves the volunteer firemen of water. They wanted more of it, and so that's how LAKEWATCH got established in state statute in 1991. And I've been in charge of it ever since.

We have responsibility all across Florida. It is a program that started with volunteers doing lake monitoring for water quality, which meant in our case phosphorus, nitrogen, chlorophyll, and water clarity as measured by Secchi disk. That's the part that initially was the selling job, to begin to get long-term databases. What happens is, a volunteer comes in, we send staff out there to train them how to collect water samples, they take the water samples, they process them at home, then they bring everything to a collection center. And the frozen samples are brought to us here at the university where our professional labs analyze everything. So there's a lag time there.

The collection site could be a fire department, it could be anyplace – we use a lot of our county Extension agent offices. And we have freezers there, they put them in the freezers, get their replacement equipment back, new bottles, whatever. And then we run someone around to pick up the water samples, because we're a big state. Now if they're very close to Gainesville, they typically bring their water in to us, frozen, because they want to see us. They love seeing the university, and they love talking to the university. But the rest of the state, they go to collection centers, where there are freezers. They put the water in freezers, the chlorophyll samples in the freezer. We also have new bottles there, and equipment there if they need it, or they go pick up new bottles for their next month's sampling, or next round of sampling, whatever it is. We do everything off of frozen water. Now, again the reasoning behind this is we don't want them trying to preserve with acid, number two if you look at some of the oldest limnological papers, they used frozen water, and when you look at variability in our lake data, it's lake to lake differences, which means sample more lakes, or it's date differences which means sample more months, it's not this QA/QC all the states have gotten into. That makes up less than 1% of variability. We wanted a simple system – makes it easy on our volunteers, and relatively easy on us. So we collect large numbers of samples, bring them in, keep them in freezers, then we'll work them up.

The primary working part of LAKEWATCH is, the volunteers go out in their boat to the middle of the lake, to three stations, and they dip clean water bottles to collect the water samples at elbow depth-length. They also collect a gallon of water in a clean milk jug that they then put in the dark, on ice if they have it there, or if they live right on the lake they go back to their house, and they filter the water through a glass fiber filter to collect the algae. They damp the filter down, label it as to where it came from, put it in desiccant, and put it in the freezer. They also put their water samples in the freezer. So that's the work part that they're doing for us.

The other part that's very critical is, they have field notes they take. They put that on the back of the chart where they record water clarity as measured by a Secchi disk. Secchi disk is very critical because it is the clarity of the water that people respond to. And with their field notes, what we find out from them is, is there something odd going on in the lake, a real windy day, or – we have a lake right now where the phosphorus and nitrogen shot way up. Well, there was a forest fire on the north shore of the lake. No one remembered that because by the time anyone looked at data, the fire is gone. It was nine months ago. But they had it recorded. So we look at their field notes very critically when an issue arises, but otherwise what they're doing is only getting the water chemistry data for us.

They generally approach us because they think something's wrong at their lake. And a lot of times, it's not wrong or broken. But these data are an insurance policy for them. They see it as a great insurance policy. They have the data, and they can use it if something does start going wrong – they can bring it forward to the parties that need to be there to fix it. I will give you an example. We had a lake in Orlando – it was a clear water lake, very clear for us, a four-meter Secchi disk reading. They put a highway along it, and next to the highway, there were posted sediment-catching cloth to collect sediments. Well, the rainstorms blew all theirs down, put all this muddy water into the lake. Well the volunteers called up DOT, and DOT said, "oh it wasn't us, I'm sure we didn't affect the lake, we have all this…" and the volunteers said, "well, it fell down." "Well what evidence do you have that the lake got muddier?" Well the volunteers took DOT the LAKEWATCH data – had all the Secchi disk readings before the event and after the event, so you went from 4 meters to a meter and a half. And when DOT saw that LAKEWATCH was involved they went, "oh, ok" and got their crews out there right away, fixing the problem. Which is what I think our public wants, to fix the problem, if there is a problem. But they're very open-minded at the beginning, as to what's the problem. Ok, make the problem the hypothesis, and we'll collect the data and either accept or reject that hypothesis. And the public likes that. They see it as puzzle-solving. And then if there is a problem, I'll walk in – they have an insurance policy if something does happen.

What that means for them is, I will look at the data, and I will tell them if their concern is justified or not, and if it is justified I will give them the names of professionals that they can call. In other words if they need professionals in the consulting business, to hire a consulting firm, I'll give them access by giving the names of people to talk to. If they have to talk to someone in the state, I know a lot of people in state government, I tell them who to call.

Most volunteers, when they come in, they believe they have a problem at their lake. That's why they want to get involved. Over time, as they begin to watch the ebb and flow of water quality over the years, they begin to become much more open-minded as to the factors that are controlling things. And they become citizen scientists, they really are interested in what's doing what where and when, and volunteers will do things as hypotheses now, rather than some lay-theory type thing, where someone says, "that's the way they are, so that's the way they are." Volunteers really become much more analytical themselves. Over time most of our volunteers have become very open-minded on a lot of things. And they receive a lot of this stuff as good. So as an example of something, nutrient criteria – that would send a citizen up the wall. We have a group of lakes here in Northern Florida – they're called Outstanding Florida Waters. Their ecological attributes are such that they're outstanding in the state of Florida, so the lakes have immense protection. Well, back in 2005, the phosphorus in these lakes went from very low levels, to up into the hyper-eutrophic level, and that caused concerns for the public. The agencies all said, "well, the public did it, you people did it by moving around the lake or other activities." Well unfortunately for the agencies, there wasn't any major development. What went on? No one could tell us what went on. Well, we finally got our volunteers, and got the field notes, and went back in time. And there was a 9,000 acre forest fire in the Santa Fe swamp area. As soon as the rains came back, that's when the phosphorus came because the fire had burned into what we call muck, burned all the accumulated organic material down, made a deep-water swamp out of it. But when the water finally came in, the lakes' nutrients went sky-high. The fire was in May, but the phosphorus didn't start going up until December, six months later. Well, the muck fires weren't put out for six months. So you begin to piece this together based on the volunteers, and they begin to say, "hey, this is natural." And they want things as natural as can be, even if it's quote unquote "bad." We have a very open-minded public.

Once a year we have a meeting with the volunteers to present back to them all their data. And at that meeting is also time for them to ask questions that they have regarding whatever issues out there at that time – so they have instantaneous feedback. During the rest of the year, however, they have the ability to call into our office. We have people to answer the phones, and I have what I call coordinators, staffing. And our staff has to talk to them, they can't just call and say, "we're on a trip somewhere we'll get back to you in a month." No, they gotta get back to the volunteers right away, within the day. So the volunteers like the fact that they can call into the office regarding problems they see, and immediately get linked up to University minds as to how you might solve that problem. Even if it's not related to their issue at that moment sampling – they're doing the sampling, but we also do things like aquatic weed control, we do fish work, we do aquatic bird stuff with them, all about getting abundance estimates. So we're really very holistic in the things we do to understand lake functioning. But we work very closely with the volunteers, they're out there getting their field notes (observations), so we have field notes of what's happening on our lakes. And as I said, once a year we have a meeting with groups of homeowners from different lakes in their region, so they also get to talk with other citizens about what's happening in their system. Because a lot of times they find out that, "oh, the state government is doing the same thing all over the place." And they may like it or they may not like it. But they get to talk with other interested parties.

For those annual meetings, we go to their region of the state. You try to minimize volunteer travel time. But once a year we also have a statewide meeting, with food, and people come from all over the state up here to the University, which is in north central Florida, because they like to see the University. But, not only do I have food, I tend to put it on a football weekend, because they like football. And, they like to come to the University and see what we're doing, and hear what the students are doing. It's a very informal type of thing where – oh, we'll have posters up, and the students will be there so they can talk to the students, but not formal scientific talks, because that bores the public. They want to ask questions, and we try to keep it very low-key to answer their questions.

Now, what this all started out with was, as I said, I came down to Florida and I was doing research on Florida lakes, relative to aquatic vegetation. When the citizens came in, part of the reason I agreed to work with them is both sides were about to gain from something. As a researcher, I could get them as workers out there collecting the information that I needed, at no cost, basically. We couldn't get money to do all this high-faluting research – at this point. But the volunteers could help out. So I was willing because I was getting workers (citizen scientists), they were willing because they felt they were getting us helping with their lakes. Now over the course of time, as a researcher, I foresaw issues that we needed to address. And a lot of the information that we were to collect from the lake groups could help us directly. In some cases, if you're a researcher you need access to a certain water body, but if you come into a group of people and say, "hey I'm from the state we're here to help ya," they say, "uh, what part of state?" "Oh the DEP, Department of Environmental Protection." "Go away, we don't want no regulators on our lake." But I – UF LAKEWATCH – come in and ask, "can I use your lake for this and that," they go, "yeah, come on in, we'll be glad to." And then they give us – hell, they give the students food at their houses. So it's been a win-win situation. A lot of it is to have the data available, have the access to the water bodies, to do the research that you need. And in our case, a lot of my scientific papers are looking across the spectrum of Florida lakes. That means you have to have access to quite a diversity of lakes. And that's what I got out of our citizen volunteers. They love working with us.

To get volunteers, one of two things typically happens, but I'm gonna start with today. We'll put an advertisement in the paper, "volunteers sought," on a given lake. Or we'd already have a volunteer. A lot of times they'll call us. Or there'll be a generic article in the paper about volunteers, and people call you because they live on a lake. Once we have their name, assuming we don't have a volunteer on that lake, we connect them to our coordinators, who then set up a training time for them. Then we drive there and we train them on their lake at their site. This is when we have money to do all of this of course.

Right now I only have two coordinators, but I had five. With all the state budget cuts, we lost a lot. And again, it's a lot of work. What we're trying to do now is get the Extension agents' role improved. Our Vice President here at the University is now convinced that UF Extension needs to be more involved. One, because USDA has a water quality program, and two, it was LAKEWATCH data that helped Florida battle US EPA on this numeric nutrient criteria stuff. They used the data extensively. So now the land-grant's really into this, apparently. We'll see. But in theory, we will train the agents to train the volunteers. And that would be good because then you'd have basically one Extension office in every county in the United States.

I had no direct relationship with UF Extension. I am a University of Florida professor in the land-grant part of the school, which is called I-F-A-S[1], which is where Extension is. Way back when, when we were starting LAKEWATCH, I had meetings with UF Extension, trying to get Extension involved. And the leadership of UF Extension – thinking this was a feel-good program – said, "no, we want to charge the volunteers fees to be involved," and I went, "hell, no." We don't charge for LAKEWATCH. Our UF Extension people, they wanted to charge. Not everyone does that. Now if you go to Rhode Island or New Hampshire, their volunteer programs are in Extension. New Hampshire doesn't charge. Of course the deans have their little strange ways of how you justify what you're doing. Universities are very political. Anyone who says they're not hasn't been working in them.

I was also dealing with legislators at that time that were mad at Extension, because they saw it as a bureaucratic ship that didn't want to change direction. So LAKEWATCH developed outside of the rule of UF Extension, which is where I thought it would go. But as a professor here, my assignment is teaching and research, so Extension wanted nothing to do with me. And then, they wanted to charge fees, so I said no and developed LAKEWATCH outside of UF Extension. And after we developed it, now we have a new Vice President here at UF, who is saying, " why aren't they (Extension) doing this?" So now they're coming back around, but it's still a bureaucratic ship that is very difficult to chase. The agents at the bottom, the workers, want to be involved. But the problem is, agents get time assignments. They have to do some project in a certain amount of time. And unless their accounting section director is saying, "that's fine, do it," – you can't work at LAKEWATCH unless they want you to. So we're trying to get that changed now.

Well, ok go back in time now. When New York was fighting the civil war and all that good stuff, you were a developed state – basically, Florida was nothing but cattle and swamp. Florida really didn't develop until, starting in about the 1900s when New Yorkers decided they wanted a place to get warm in the winter. So we started building all the railroads. Throughout most of our history, we were a very rural, undeveloped state in the 20th century. And it wasn't until about, oh, the 1960s, let's say, that the wealth of the state got enough that you started putting government agencies in place to look at the

[1] The University of Florida, Institute of Food and Agricultural Sciences

environmental issues. And certainly, with the death of Lake Erie in the papers, that started it, when the EPA came about, about 1970, I think it was, right? So we started to develop our state agencies, but the agencies couldn't sample all the lakes, because we have over 7,000 lakes. So they really weren't doing anything but maybe one or two of the major ones. By the 1980s, the environmental concern about water was pretty strong, but there was no money in the state coffers to hire people to go out and sample water. So we basically ended up going with the volunteers, as in demonstration form.

Now through the '80s though, or by the '90s, Florida got to be a very rich state. And by rich I mean our population exploded, and with that came development, and all the things that come with growth. And we, as a state, got a lot of money. And because a lot of the folks moving into the state came as retirees from the northern states where there are really clear waters, they were concerned about our waters down here. So we got a very strong environmental contingency down here. And that's when Okeechobee became an issue[2], Apopka became a hotter issue[3], and a lot of money to the water management district started flowing into the professional coffers to do things. To begin, they only focused on a few lakes. LAKEWATCH, by the beginning of 1990, was beginning to develop this longer term database, because a couple senators basically jumped on it, got it in the state budget, and it went through pretty well, up until this last round of budget cuts when everyone got cut. The advantage to it now has been, ok, we've been here since – start with 1990, through the population growth – it went from 6 or 7 million people in the state of Florida to over 14 million. And a lot of growth on the lakes, a lot of houses, and people were asking, "what has happened to the water?" Well, we had the data saying, "here's the lakes that changed, here's the lakes that didn't change." If it changed, was it due to growth? Or was it due to some other factors such as hurricanes, or natural factors? So that's why they're now seeing the value of LAKEWATCH data.

We get allocation money right direct from the state legislature. In every state, you have programs that can either be in agencies, or if the agencies don't want to do things the legislators have the right to establish things in law – in Florida law, it's called statutory law. And so it was in under Florida statute that the legislatures created LAKEWATCH with the power to do what was needed to make it into a very effective volunteer program. It gave us freedom away from a lot of the agencies that would put restrictions on what you do, including the University. So we have a certain amount of independence

[2] For a history of the controversies over natural and cultural eutrophication, see Steinman, A., K. Havens, and L. Hornung. 2002. The managed recession of Lake Okeechobee, Florida: integrating science and natural resource management. Conservation Ecology **6**(2): 17. [online] URL: http://www.consecol.org/vol6/iss2/art17/

[3] Canfield summarizes the challenged environmental history of this lake in: Canfield, D. E., Jr., R. W. Bachmann, and M. V. Hoyer, 2000. A management alternative for Lake Apopka. Lake and Reservoir Management. (16)3: 205-221.

that a lot of organizations don't have, because our people went to the legislature and said, "this is what we really need." So we're in Florida state statute, Florida law.

The legislature got this into state statute because two powerful legislators, one senator and one member of the house, saw in the 1980s the potential value of having lots of information on our waters. Now what happened was, we got a bill before the House of Representatives the first year. It failed. The reason it failed was because the lobbyists were against it, because they thought environmental activists would have access to say ag was bad, the cities were against it because they thought you'd have all these accesses on their storm water cases, and the environmentalists didn't want us, because they felt we'd be getting data that says there isn't a problem. When the senator and rep that finally put the bill forth, to the legislative session their statement to me was, "well if everyone hates it, it must be good." And they pushed it through, because they said, "no one has any data, so let's not be afraid of the truth and see what we get." So that's how LAKEWATCH came about.

And they, the legislators, obviously are people-related people and they saw the need to work with people. A lot of agencies don't work with people. They say they do, but they don't. They have public hearings or whatever, but they're not really working with the people. The legislators saw this as a true people-driven operation, so they put it in a state statute. And I think the other part of it – and it might be me as an individual – when you go into your classes at the university and you're dealing with a lot of the environmental types, why did they go into the field? A lot of times they went into the field because they really are hoping to get away from people – be out in the woods and see the birds and trees and water, whatever. But the people-oriented people are in the non-sciences – in psychology or political science, or law school, stuff like that. So I was sort of seen as a unique scientist who could talk the language of the everyday person. In other words, when I talked to senators, I didn't use all our big scientific terms, I tried to bring it down to something they could understand. They like that. So, that's part of the reason why, because I am a firm believer of working with the people. I trust them and I pretty much have learned a lot from them over the years. So that may be the other part of the uniqueness.

It was the people that brought LAKEWATCH to their attention first, and then the legislators found me, and we had a long talk, and then they confirmed what they were hearing from their people. So, that's how it all came about. But at least when they talked to me I was positive about it, which was different from a lot of university professors who didn't want to work with the public, they just wanted to get some money for their research. But I was willing to work with the citizens on a basis of trying to help solve problems.

And with this legislative appropriation, I typically do not have to deal with a lot of the stuff that others do. The money is transferred into the University of Florida, but the University of Florida presidents and deans and chairs don't control it. I control it, as head of LAKEWATCH. We use that money for equipment, we use that money for staffing, whatever we think we need to for the good of the program. At a lot of universities you might run into, "well, you have to use *x* amount for staff, or you can't buy equipment with it, or you can't…," you know, everyone has an office that controls what you do. I will give you the best example I can think of. Why do volunteers come to our LAKEWATCH meetings? Could be because they're interested in science. But at every meeting, we have food there. They come for the dinner – people come from all over for the food. Well, under the University regs, you can't buy food. And yet, one of the statutes says, "do what's necessary for the good of the program." Buying food is what gets volunteers to come away from their homes to an evening meeting, and so we have an exemption for buying food because of that. Which aggravates a lot of people, but so be it. And the volunteers, while they're eating they get their meetings – we get a lot of people to our meetings that way.

Where politics does affect things is you have people say, "well, why don't we do the research with so-and-so?" Well, they want ten times the price of others, so I say, "no, the citizens are doing fine." Sometimes UF Extension gets mad, because you got citizens working on something, and they want to put it into one of their programs, and say, "well, we want all the pennies, but we don't want to work with the citizens per se." So, there's those types of things, and then of course there's the politics that come about with getting students to do research in the applied area, because some faculty don't think that's research. They think it ought to all be basic research. So you have problems with students and that, but like I said, I just do my job, and over the years things went my way, and now I'm an old geezer professor, and they don't tend to bother me too much. But you run into things like, we have a chemist position that came out of the university budget in 1979 that does all the water chemistry. The university got tight in 2008 with money and they cut our money for the chemist position. Why do they cut it? Because they feel we'll go to the legislature and get other money. They'll use that money for something else. So that's the type of stuff that politics get involved in. It's all about who has money and who's trying to do things. But you can't worry too much about that, you gotta keep your eye on the prize.

I grew up in New England. I went to a college, Bates College, in Maine, which isn't an Ivy League school, but one of those second-tier private liberal arts schools. What I found out over the years, as I went to track meets at Harvard and places like that – they're very good schools, but they are in it for something other than the community. The land grant institutions are in it to, quote-unquote, "better their communities." And early on, with land grants, it was research and agriculture, or teaching, or Extension – Extension was the teaching of what we found out in research to the public, to benefit our communities. I think it's a great model for doing things. Extension used to be this system where you had agents in the field, they would get questions from the public, they'd come back to the university, talk with researchers, who would then investigate certain things, and they try to answer the question to help that community get the answer, solve the problem so to speak. Then teach it to those in college.

Now over time, well, the last decade or so, I find the land-grants have become very much money oriented. By that I mean the Federal government starts pouring in lots of money, and the land-grants say, "oh, we want to be Level One researchers, we want to be like Harvard, and Yale, and all them." No. You mess up your mission, which is to work with the people. And a lot of our administrators now are not land-grant trained people. They do not understand the mission. So what happens is, rather than turn into our Extension agents, where there's one in every county in the state, practically, and ask them how can you work with our people, how can we get information back to you, have them say, "ok this is the research we really oughta be doing, or looking for." It's very applied-oriented, where a lot of the other stuff is more esoteric research, or it's not so applied at the moment. But administrators would say, "oh, we gotta do that because that is where the big dollars are." Well that's fine, we do. But again, I think you need those people that are out there willing to help that community. And that's where a lot of our land grant universities are crazy over the big federal dollars now. The more money, the better off we are the administrators think. And they haven't been supporting Extension. In part because Extension was developed for agriculture and agriculture is not as big as it used to be. So a lot of different things are happening philosophically, I guess is what I'm saying.

So, Extension started getting their monies cut at the state level. And rather than stick to their mission, they started hunkering down, and they got into, "we can't do anything any different." What happened down here in Florida was, we used to call them Extension Agents. Well, that's bad – now we call them faculty. They had to move into the "faculty," quote unquote. In order to keep their jobs, they would need tenure promotion, they gotta have research dollars, they gotta show that they're good in two out of three areas – teaching, research, Extension. And so now they started moving over, and these services got to be very closed-minded about anything from the outside. Where in the old days, researchers could talk with Extension agents, Extension agents could talk with researchers, teachers, whatever. And so, we put these stovepipes in place now – no cross-communication, cross-fertilization. So in my case, with UF Extension, "oh that sounds like a good idea, but what we need is to be charging all these people." "Why?" "Oh, we need the money." "Well, you gonna put the money back in the program?" "No, we'll take it to the dean's office and we'll distribute it how we want." Well, that's not the way to do business. So that's why I think there's a problem. I think it's the mentality of the university presidents, they all look at more and more research dollars, coming in to support their universities, because the legislatures are cutting back on a lot of the funding, as they put it into Medicare or social support programs like prisons. So university administrators see research as a way to get new money.

Let me see how to put this now. You know President Eisenhower, right? He was a General, during World War II. And he was the great political leader of that European Army operation. General George Patton was not so well liked because he was a bulldog. But if you had to have someone relieve the soldiers at Bastogne during the Battle of the Bulge, you picked on Patton, because he said he'd take the Third Army up there in no time. Well, I'm like Patton. Give me an objective, I will lead the charge, and we will successfully win the war. But if you want me to play nice politically, I cannot do that. So when UF Extension got involved with their leadership team, and they asked questions about, "well, what's wrong?" I tell them what's wrong. That of course didn't endear me to their leadership. But now it's come back around after 20 years, and they're trying to work with us. So in our case, LAKEWATCH, the only way it could develop was independent of an Extension. But Extension's the natural place for volunteer monitoring – because you have USDA money, for water quality, you can get EPA money, you should have the state government wanting to do it too, you know. So that's my storyline.

Also, federal law has changed. The US-EPA wants to go to quantitative nutrient standards, not qualitative. So if you go to the newspapers right now, the US-EPA is trying to force upon the state of Florida a Numeric Nutrient Criteria, for the greater good of water quality. And in that, if the states adopt these quantitative nutrient standards, they have to have a way of documenting whether things are changing or not. In our state right now, our DEP finally says, "hey, this is the way we could do it. We could do it with the volunteers, because we have enough data from large numbers of water bodies to be able to say what's happening to the population of the lakes." So that's why we're getting more support now, again. The Florida DEP finally agreed that they want to use our data, and they put us in their budget for the first time. They never put us in their budget as long as the legislature covered us. But they put us in their budget for the first time after this Numeric Nutrient Criteria debate, because they realized they need the data, and they're not gonna get the data hiring more government workers, because that's not what the people want. They want more done for less, as they say.

Well, in doing their process, the US-EPA basically ignored all the natural factors that influence water quality in the state, and they tried to come up with a one-size-fits-all. With the LAKEWATCH data, we were able to show that, well, lakes are individuals, but more importantly you have to consider your soils, what they call edaphic factors, which they didn't bring into their mix. So, why is that important? Well, in other words, they wanted to make all our lakes oligotrophic or mesotrophic, which means unproductive, and no lake should be eutrophic, meaning productive. If they're eutrophic, they're impaired. So in Florida, 67% of our lakes are "impaired," – it's gonna cost us tons of money to fix this stuff. Well, what EPA forgot is, we mine phosphorus in the State of

Florida, the limiting nutrient for all this biological productivity. The phosphorus accounts for 75% of the phosphorus in the whole United States. So we have lakes that are naturally eutrophic. And we had paleolimnological cores which showed the lakes were eutrophic from day one. We have twenty years of water quality data you can do all your fancy stats with, and the lake's aren't changing – you cannot relate it to land use.

So a lot of people went, "wait a minute, this numeric criteria, which we all want to do, the way the EPA came up with is not the right way to go." And so our governor, our agriculture commissioner, our attorney general, our legislature – everyone is on the EPA now, because they would have cost us billions of dollars uselessly. And the LAKEWATCH stuff has helped make the argument in part that EPA is misguided. I would say that's our biggest effect right now. Which is going back to the real basics of limnology – what makes lakes what they are. You gotta understand your soils, you gotta understand your morphology, you gotta understand hydrology, and our lakes down here – some are as crystal clear as they are in New York, but in New York, you don't have all crystal clear lakes either. In farm areas they tend to be greener. Well, as I tell people, you don't farm on top of the Adirondack mountains, farm down in the valleys where the rich soils are. So you gotta make a judgment between what's natural, what's not natural, and what are humans really doing and not doing. You – EPA – just can't come in and say, "oh, any lake that's eutrophic is bad." No, no. Some of our waters are that way, that's why we have lots of alligators, lots of fish, lots of other things. But I think that's one of the big things from LAKEWATCH right now, is getting the database to address these long-term questions, after 20 years.

I think the way my own research evolved is, the citizens were the eyes and ears out there – for example, the forest fire thing. Fires mostly don't influence water quality, according to our forestry people. Well, you find a fast-burning fire up in the hills, and that's probably true, it doesn't. But then when you get into these big muck fires that burn down the organics on the ground for 8 months on end, we started finding, yeah, it did influence a lot of lakes. So here's a system where a natural catastrophic event is influencing lake water quality. That's made me go back in time in our long-term databases, to look at other natural catastrophic events, as they call them. Hurricanes – we now have the data to show what the hurricanes do, or droughts do, or do not do to our lakes. So it's helped me begin to realize that we have to look at the natural factors a lot more closely, and not always say, "well, humans did it," because a lot of times the human effect isn't as great as we think it is. So that's one influence on me. I began to realize the value of long-term databases, where a lot of us, in the old days, three years of study was enough, move on to the next one.

Florida is a little different. In New York you had Cornell working up there in the 1800s. In the 1800s, Florida was a swamp filled with Indians that we were trying to exterminate. We really didn't begin to develop it until the '40's, and in terms of water quality in our lakes, the first samples were collected in the late 1950's, early '60's. So we had no long-term database beyond one or two lakes, period. So Florida is unique in that regard. Where you get up north, people were studying the lakes up there in 1900, 1903 – our first really good databases don't start until 1969, from Fish and Game. And that was hit or miss also. So LAKEWATCH did fill that need.

My idea when I first started up was to get a better feel for the edaphic factors. That involves the soils, because if you go back in the history of limnology, way, way back, where they developed what was called the trophic state concept, they very carefully said you have to know about your soils, recognizing that the greener lakes tend to be in agricultural calcareous soils, and the clear water lakes tend to be in granitic basins. So that's when you have the big mountains, whatever. And so when I came to Florida, I did my survey of lakes[4], I was attuned to that because lakes are different, and I wanted to see if there were patterns. So I started working on a lot of that. And when the volunteers first came in, I went, "hey, this is a way to get data from a lot of lakes." So yes, I sort of knew they could fill a need. Did I really know where I was going? No. So a lot of it was fortuitous, but I realized that I needed more data on more lakes, so that's why I got interested in it. And now that I have the long-term records, it's opened up a lot of other doors.

If you look at the science out there, I got my name in – almost all my papers are with LAKEWATCH data[5]. We used LAKEWATCH data extensively, on the basic limnological questions. Now again, here's the problem that you run into. Most egghead professors that you talk with will tell you that citizens can't do it. "Oh, it's not as good as doing it ourselves, or getting our own people up there." But the data are as good as things the professionals collect[6]. And you're able to use this data because you get so many water bodies that, in the empirical science anyhow, it gives patterns of what's going on. So in my case, it allowed me to help develop the Lake Regions of Florida[7], which is the big thing that says, "ok, these lakes over here are green, these lakes are crystal clear, these lakes are acid," so, you get the effects of geology on our water chemistry. It allowed me to look at aquatic plants in our lakes. What are they doing in terms of wave control, and how much does it affect water chemistry? Because one of the things the volunteers do is they give you access to a lot of waters where there's no public access, so we're able to get plant data from a whole host of lakes. Like we used it for trying to understand aquatic plants in lakes, and the management of them. It's got us into lakes to look at fish

[4] e.g., Canfield, D. E., M. J. Maceina, L. M. Hodgson, and K. A. Langeland. 1983. Limnological Features of Soma Northwestern Florida Lakes. Journal of Freshwater Ecology **2**:67-79.
[5] For a selection, see http://lakewatch.ifas.ufl.edu/Recommend.htm
[6] e.g., Canfield, D. E., C. D. Brown, R. W. Bachmann, and M. V. Hoyer. 2002. Volunteer Lake Monitoring: Testing the Reliability of Data Collected by the Florida LAKEWATCH Program. Lake and Reservoir Management **18**:1-9.
[7] Griffith, G. E., D. E. Canfield, Jr., C. A. Horsburgh, J. M. Omernik. 1997. Lake Regions of Florida. US EPA Corvallis, Oregon EPA/R - 97/127.

populations. And aquatic birds. So you'll see in my career, I've gone away from chemistry on up to plants, on up to fish, on up to aquatic birds. That's all because of our volunteers. We're getting bird counts on these lakes now – everyone loves to count birds, because they see the birds – they go around the lake in their canoe or their boat, counting birds as they go around the shore. It's a technique that we've put in the literature, and keeping track of birds so they don't count them twice, but they're doing the shoreline surveys of birds. We try to get help with fish stuff – that's more electro-fishing, but having volunteers still helps us with access. So it's mixing the bird stuff with lake stuff with – I've found this to be a very productive process for me as a researcher. It permitted me to be a generalist rather than a specialist.

Some of the volunteers also do the Christmas Bird Counts for Audubon, so we can put the data in for the Christmas stuff. You try to standardize things relative to whatever you're using so that you get the most bang out of the buck. But we didn't get into these fancy transects that everyone wants them to use, because again, remember, people are out on the lake to enjoy themselves. And observation being the first step of science, they're our eyes out there. So we've had good luck with the bird counts. In fact we did a study with the bird counts with volunteers – one of the water management districts was interested in bird species in the area of the water. Well, they don't like the volunteers, so they hired a consulting firm on contract – $215,000 later they said, "oops, we got the exact same answer as the volunteers." So there's a story there[8].

We've had good acceptance of the scientific research, because we verify it based on professional vs. volunteers comparisons. Other states have too. So, over time, it hasn't been a big issue. The thing that you get into is, bureaucrats want to have QA/QC according to this protocol or that protocol, that you can't do with the citizens. Like putting acid in water to preserve it. Well, I think, "giving people acid in their homes is not a good thing to do, because what if a kid gets into it and burns themselves?" So then I go back and think, "well, how did we do it before we had acid?" Well, they used to freeze water samples. As soon as I said, "freeze it," all the agencies, in particular, said "you can't do that." I said, "why? we do ice cores and stuff…." "Nope, you can't do it." So we did a bunch of tests, holding water frozen up to 6 months, which is about as long as it takes us to analyze samples, and we found out the frozen waters gave us the same answers as the acid waters. So there are times you have to do things that prove to the people that the simpler way is the easier way to do it.

The journals have been more than open to this work, because the journals are more about ideas than the actual collection of the data, as long as you're in the right ballpark with things. They understand that everyone has problems – citizens, students, whoever – when you're publishing. But we had good luck, and our use of volunteers is in a format

[8] Hoyer, M. V., J. Winn, and D. E. Canfield. 2001. Citizen Monitoring of Aquatic Bird Populations Using a Florida Lake. Lake and Reservoir Management **17**:82-89.

that we get information that is acceptable, and I think that comes about because I – early on, and my colleagues – all believe that you can collect very credible information with volunteers. And some of the other volunteer groups around the country have done the same thing. They've shown the data are credible. But a lot of the professionals still say bad things about it because I think they're just fearful that the citizens are gonna replace them in monitoring, and professionals love monitoring cause it gets you out of the office and doing things, whereas you don't have to be responsible for fixing things, which is what you got hired for. But all across the country volunteer data has been very credible, and that's helped in a lot of the publications around the world. In some cases, many professionals just use the volunteers for feel-good stuff – they measure oxygen, but they don't tell citizens how to assure that meter is working right. There's a lot of people like that because their goal is to communicate agency dogma. But in our case, most of the volunteer stuff has been involved with things that they can do, and we've shown that they do just as good a job as the professionals.

When I say "professionals," I mean anyone in the field of aquatics that is monitoring water bodies – agency personnel, and environmental protections groups, EPA, groups like that. Even university scientists who want to have all this research money coming to their place and doing it less expensive. They say, "oh, give us some money for the volunteers," and then they sort of pat them on the head and don't really involve them in their things. And I think that's been part of the problem over time. The citizens can monitor nearly anything you need, in terms of collecting the samples and getting them to the research labs, where you can analyze them.

Now a lot of the professionals, even university professors, do not want to work with citizens on a day-to-day basis cause they're perceived as too demanding. But I think they're asking reasonable questions, and the best ones are the one that you do not expect. You go to the meetings, and you might be thinking they're concerned about the water quality, because that's what they've been measuring, and along will come a question like, "I was walking around the lake, and my foot sunk into a hole, and I got a burning sensation. Why is that?" "Well, that's hydrogen sulfide in the mud, called hot mud." They might ask a question about fish behavior. They ask almost anything under the sun. And so I'm a little more attuned to that, because I'm a generalist.

And as a generalist, I read a lot of the early limnology textbooks. Needham's 1915 book, The Life of Inland Waters[9], is neat because it talks about a lot of things that got us in the professional realm interested in lakes. They saw wisps on lakes – will 'o the wisp – what does that mean? They saw different waters doing different things, fish who die, fish who live – I mean, a lot of the things that limnologists saw on lakes over time are things that the citizens see. The volunteers are being scientists, they're being citizen scientists. And

[9] Needham, J. G., and J. T. Lloyd 1916. The life of inland waters; an elementary text book of fresh-water biology for American students. Comstock Pub. Co., Ithaca, N.Y.

so they like to ask you questions. We'll have events down here, for example, "oh, my god, our lake is putrid yellow-green." They moved down from up north, New York, they come down here, they never saw this before. Our pine trees, when they release the pollen, will just make these lakes all green. They'll ask about that. Or they'll have an emergence of midge flies and they want to know about that. So you never know what they're going to ask you at any given moment. And the big thing is, if you don't know, say, "hey, I don't know, but I'll try to find out for you," by going back into the university, Central Service or whatever, and finding someone that might have an idea what they're looking at. The volunteers like people that talk with them.

LAKEWATCH is viewed very positively by virtually everyone. And in part that's because I don't tout myself as the leader and director of LAKEWATCH. I try to keep my controversial research stuff separate, and over time, people will find out who I am. But a lot of times they don't recognize who I am. I mean, I've been involved in things like the eutrophication of Lake Okeechobee down here[10], Lake Apopka, Rodman Reservoir[11] – big controversial issues that the environmental community, for example, is promoting. Then I come out and say, "wait a minute, you got no clothes on, this is wrong," and people get upset about it because they think I am not concerned about the environment. But they didn't really realize that I was running the LAKEWATCH program all the time, because I have other staff members, that I call the field directors. They associate with people a lot of times rather than me, because I know I'm controversial. At the same time, over the long run, people finally figure out that I am the voice behind LAKEWATCH and they took pause. But now after 20 years of it, it doesn't matter as much, now.

I grew up in Connecticut in an area populated with "Cantankerous Connecticut Yankees" And I am one. One of the things that I've always been above-board about is that in science we have hypotheses, and we have theories, and most of what we do in aquatics are hypotheses, not theories as said in the papers. I've been very frank with whoever I talk to, the way I see the world going is based on what the data says. By being truthful, that has garnered me the respect of everyone over the years. Because it may be an issue that Senator *Whoever* hates at that moment, but ten years later the Senator say, "well gee, that's true." So you just gotta be above board and open, and as long as you don't infuriate the people, whoever they are, by trying to demean them, you treat them like your family – people were pretty good.

[10] e.g., Daniel E. Canfield Jr. & Mark V. Hoyer 1988. The Eutrophication of Lake Okeechobee, Lake and Reservoir Management, **4**(2): 91-99.

[11] In the mid 1990's Canfield and colleagues weighed in on an ongoing controversy as to whether to remove Rodman Dam on Florida's Oklawaha River, submitting a 50+ page document entitled "'To Be or Not To Be': The Rodman Reservoir Controversy," which has been documented in a 2009 history entitled "Ditch of Dreams: The Cross Florida Barge Canal and the Struggle for Florida's Future (Noll and Tegeder, University Press of Florida). In their opening statement they suggest that the TEAM Approach, which Dan describes later in this narrative, be used help resolve the conflict. Online: http://www.rodmanreservoir.com/2bornot2b/to%20be%20or%20not%20to%20be.htm

And one of the things most people say is, "well you don't seem like a university professor." I said "thank you." We professors today have a lot of baggage in the eyes of the general public in certain ways. So when they say, "well you don't seem like one," that's good to me. It's a lot of different things going on in people's minds. But on my research end, I do a lot of research that – we're testing hypotheses, and the data supports or doesn't support, and so a lot of my papers tend to be controversial. With a lot of these lake management issues where my views differ from the conventional wisdom, my opponents sometimes say, "oh, he's a rogue scientist," in an attempt to demean me. Well, no, we deal with the data and publish the papers, and we'll see where science takes us in the years to come. But I'm putting out the way I interpret the data. I don't worry about what people think about me.

Probably the next step for me is the development of comprehensive lake management plans for individual lakes. And with that, I have authored a paper with my former wife, called "The TEAM Approach," Together for Environmental Assessment and Management, where we bring in citizens from all walks of life and of all different viewpoints[12]. We sit them in a room for a day, and say, "what do you see as the problem?" And they start with 10 million problems, but by the end eventually it comes down to four or five problems. And then we take that (the four to five problems) to the scientific community, and I'm saying, "ok, what do you see as the problem with what the citizens are saying?" And then that forces scientists to say, in a written document to the public, "ok, where do you agree, where do you disagree, and when you disagree, why?" And write it in 6th grade language so the citizens can understand it (forget the big technical words). We'll go back to the citizens, and they're very good at saying, "well this is the way we think we want to solve our problem, to manage the lake," and you end up with a majority view and a minority view. So you say, "ok, we'll monitor for what the minorities are concerned about, and if the data begins to support the minority view, you could always change your plan up." But a lot of times, it's not that hard a subject. You can prevent a lot of problems at the lakes by involving the citizens, because – there's a fellow by the name of H.A. Simons[13] that says, "If you expect significant changes in the behavior of people, you better have them involved in making the decision for that change." And so, I see a lot more LAKEWATCH involved in getting the plans put together, so that we know which way to move to solve

[12] Outlined in Canfield, S. L., and D. E. Canfield. 1994. The TEAM Approach, "Together for Environmental Assessment and Management": A Process for Developing Effective Lake Management Plans or Water Resource Policy. Lake and Reservoir Management **10**:203-212.

[13] Referring here to Herbert A. Simon, political scientist who wrote, among other things, Administrative Behavior: a Study of Decision-Making Processes in Administrative Organization (1947) and Models of Bounded Rationality (1982; 1997). A similar statement in a paper by Canfield and Canfield is attributed to Simon, H.A. 1955. Recent advances in organization theory. In S.K. Bailey, et al., Research frontiers in politics and government. Brookings Institution, Washington, D.C. Simon identified as a logical positivist, and with what he later called bounded rationality. This approach views people as rational, and trusts that facts will outweigh values in decision making.

problems, working with the agencies. Time to get some of them – agencies – more people-oriented in that regard.

The other thing is, you know, I think a lot of our folks – scientists – are adverse to conflict. They see conflict as very difficult, and I see conflict as something that is creative and simple to deal with – conflict resolution comes down to the following three things: one, “Did I get what I wanted? If I got what I wanted, then there’s no conflict, right?” Two: “Was I treated fairly?” No person likes to be treated in an unfair operation, like saying, “you’re an idiot” or whatever. You just gotta work with them and say, “ok, your concern is a hypothesis, a working hypothesis.” You don’t just discount them. And three: they gotta know the *process* is fair. If they think the process is unfair, they’ll come in at the last hour and fight you tooth and nail forever. So really, to resolve the conflict, you only need two out of those three things. The TEAM approach is to make it as fair as they can, and then treat the people right, so you got two out of the three. So nine times out of ten, when we’re done with these TEAM meetings, people accept it. And then the minority hasn’t been thrown overboard, they say, “ok, we’re gonna monitor for this stuff.” So I see a lot of direction related to how we’ll work more closely with the people again. Rather than getting away from it, which is what a lot of groups have done.

We put that together on how to resolve big environmental issues, because you’ve got groups from all walks of life having input into it, and how do you get to the point of making it fair to everyone, and at the same time come to a timely conclusion? Because Americans hate things that don’t come to conclusions. They don’t want to hear about more studies, unless they have a reason that they said, “do it,” you know? So it’s an interesting paper that I’ve been working on with the lakes down here and TEAM seems to work pretty good. So, work with the people, be open-minded, try to be fair to them, and see where it all goes. Don’t be worried about conflict.

TEAM is related to LAKEWATCH, we developed it, we use it to try to help our citizens resolve conflicts, and give them a direction of which way to move, but still do the monitoring. So if the minority view is right you could change. But if the majority’s right, instead of talk, talk, talk, it gets things done. Now, with that said, I developed the TEAM approach because, from my volunteers, I kept hearing they’d go to public meetings, they’d never get to talk, or someone dominates the conversation, or the agencies have a hidden agenda, people were very upset. So we went with TEAM, to say, “ok, we’ll bring all the citizens into one room, we’ll get all sides to the stories there, and try to get the activists along with the non-activists there.” And go through them, and say, “ok, what is the problem here?” And of course, the first round you get ten million problems. But over time, they always come down to about, say, five.

And then you can go back in – once you have their issues, the real issues – and go into the science. And recognize, science doesn’t always agree, but we have more agreement 95%

of the time than most people believe in. And from the management standpoint, you come up with a good pro/con debate, so the citizens can understand what is going on here. And then you bring them back in with this document, so they get – instead of hearing what's in the newspapers, they actually get to read it. And the pro and con, and then they can make a decision. And typically they'll make the recommendation which way to go, and as I said, the majority recommendation – being the US of A – how to move and monitor, and if the minority is right, then you can change. But you never say anyone's wrong. I guess I'm being Eisenhower now, right? But again, it's still the problem that Patton faced, that you gotta get through all these people that say you can't do it, and get back to the guys on the ground and say, "how are we gonna do it?" And that's what it's all about, with conflict, is trying to get our management heading in a direction that the people can agree with. Because as it is today, an activist group will drive it – they go to court, or whatever – it's not what the majority's seeing. It could be a disease-of-the-day phenomenon, you know, well, it's all about hydro, or it's all about nutrients, or it's all about climate change. People have lots of concerns but they want a fair debate as to which way they go. And you work your way down to the first part of the TEAM, with going from ten million problems down to a couple of what they're really concerned about, but you're letting everyone talk so the individual does not feel they've been discounted. Whether they have a PhD or if they're just a local iron worker, you know? Everyone's the same.

TEAM grew pretty much out of the Lake Tsala Apopka's event. They had a citizen group over there called TOOFAR, which was a group against taxes. You had agencies proposing things like sewer collecting lines around the lake, you had people wanting to deepen the lake through dredging, you had people that – they had a big dam on the river, an inflatable dam that can inflate to put water into the lake, and deflate and let the river run so the water wouldn't go into the lake, and there was water level concerns, and – a whole host of things – weed control, no fish anymore. And they had a preserve inside the lake boundary called Potts Preserve. The horse people wanted to have horse-riding trails in there, but it would cut off that whole preserve to all the fishermen and froggers and wildlifers and all that. So we had a whole host of people that had different agendas, and that was where one of the legislators came to me and said, "what would you do to solve this? Because it's a nightmare down here." So that's where we used TEAM. And when we got done with it, the County Commissioner called me before the commission – I figured I was in deep doodoo – and he went, "I congratulate you. Never have I seen anyone bring together southern rednecks, northern Yankees, people that don't care about the environment, people that care about the environment, and get them all working in one direction." So that was where we started it. Now the problem with it is, people change after five years in a growth state like Florida. They'll come and go. So you sorta have to be willing to redo it every so often. Society changes. They'll probably end up with the same answer, most times, but if they think they know better than you, they're gonna cause ruckus. So you gotta let them work through it. And in my TEAM paper, there's a quote there, under the title, if you expect changes in human behavior, significant changes, they'd better be participants in it. Otherwise they're gonna fight you forever and a day. So, that's how it came about.

As I said, I grew up in New England, the state of Connecticut. And I grew up in North Central Connecticut where we're known as cantankerous Connecticut Yankees. And I was schooled very much in our founding fathers and the constitution, the Republic, and treating people fairly, and all that. And I got to see, as government evolved, you've got arrogance of government, and that. And when I got down here in Florida, I saw it manifested again, because as a growth state we had people not only from New England, but from the Midwest, or the far west, they always come to Florida with their regional ideas. My thing is lake management. I got to thinking, well, how do you manage things? There's a right way and a wrong way. The right way is my way. The trouble is the "my" wasn't always Dan Canfield's "my." It was Suzie's "my" or Jack's "my," or… So I started saying ok, how do you bring these people, that basically hate one another, together? And that's where I went back to our founding of this country, the constitutional meetings and stuff like that, American assembly conference, because we're a country based on individuals that want to remain individuals and not be clumped in with someone. So I started reading about the American Assembly Conference[14], and I kept thinking, you know, this could work, modified somewhat, because we can't always have a hundred people.

And then I had to bring science into it, and I went, "ok, how do you bring science into it?" because all the scientists have different opinions also, because they're people. So you get the issue, you get them to write about the pros, you get someone to write about the cons, get both sides up there. And after they dance around a bit, in simple language say, "ok, where do we agree? Where do we disagree?" And, like I said, when I did that with people, on the science end, there's generally 95% agreement. And then part of them was something that monitoring could help on, or something like that, people say, "wait a minute, we'll take the risk and not go this way, or that way." Because in science you always have someone at one end of the continuum, or the other end of the continuum, and sometimes you can't even rely on the vast majority to think it's right. Because they – people understand Galileo pretty well, you know, but most scientists said the world wasn't round. It takes a while for science to work. Science does not necessarily work at the same speed as politics. And so by mixing the science with the American Assembly Conference, I found a way that I felt we could bring science to bear more fruitfully than just having the politicians say, "yes science is nice, but we're gonna do the politically correct thing." So I guess it's a combination of my experiences over time.

[14] The American Assembly, at Columbia University, describes itself as a "national, non-partisan public affairs forum" (http://americanassembly.org/) that commissions research on public policy. It was founded by Dwight Eisenhower.

We still use the TEAM approach, when they ask us to come in to assist. We've done Coastal Dune Lakes up in Walton County now[15]. Then again, it takes money to do this, and with the budget cuts, we've pulled back a lot. We have seen people are frustrated enough that they want it done, because in America today, you convene a public hearing meeting, or – you know, the agencies all want to do it themselves. And it's not 'til people are so mad they're ready to have a revolution that we get called in. Typically it'll be the political leadership at the local level, the citizens around the lake, they'll get their leader to say, "hey, we need something different here." And they convince their elected officials that government's not doing things the right way, and they want a fair hearing, is what they say. They see it as more fair. And again, the word "fair" comes not from me, but – after we did the Tsala Apopka one, the message went out via the citizens. But we did Walton County and the citizens all sides that they felt fair. Dan Canfield is the founder and director for the LAKEWATCH. I use TEAM to help resolve problems for LAKEWATCH, so it is a tool that LAKEWATCH can use. But we don't do it at every lake – it's gotta be a big issue. It doesn't have to be a LAKEWATCH lake, but generally people pick up on it because they know about it. I do not promote it in the public arena *per se*, because I don't have money to do TEAM at every lake, every water body. And, there are conflict resolution groups out there, so people pick up on them. But the citizens like us better than the conflict resolution, because of the way the American Assembly Conference stuff works. Because we're treating every individual as an important individual, no matter what side they're on.

We use whatever data are available. The LAKEWATCH data are just water quality, so if you're into water quality, that's fine. But a lot of issues don't always deal with just water quality, or water chemistry. At the Dune Lakes up in Walton County, there's a big hydrological component, so we had USGS there, we had the ground water people there, state government. So LAKEWATCH data could be used, but when they ask us to do it, they come to us because they trust the process based on what those citizens have said.

Right now, my work with LAKEWATCH is received at UF very well because I'm a senior tenured professor, and I'm old enough now that I oversee faculty tenure promotion. So let's go back to the very beginning of my career. A lot of faculty don't think we should work with the people. Researchers should be researchers, Extension should be Extension, and never shall the two mix. I was of the firm belief that, "well, we're hired by the people, so let's try to solve their problems," no matter what file they put me into. So within the university, we did not have a lot of support at first. I got some support from the leadership, the Dean of Research who was interested in water, but didn't know how to move ahead.

[15] Report available at: http://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&sqi=2&ved=0CCQQFjAA&url=http%3A%2F%2Fwww.basinalliance.org%2Fdata%2Ffiles%2FCDL_ProsAndCons_August2008.pdf&ei=mg5tUIKoF8Ph0QHYnIDgAw&usg=AFQjCNHLBizv1L9RCl0rVmZvbkAv3yNPNg

Let me go back in time again. So you go to jobs, you interview. In my case, I interviewed in the School of Forest Resources and Conservation, and apparently at my interview there were two faculty members that were go-getters in their group, that liked what I was saying. Now the faculty – I find this out after all these years – voted not to hire me. Those two faculty members went to the Director of the School, to the Dean of Research, to VP, and said, "this is the guy that we want, this is the guy that we need." So I got hired. So the first part of my career, relative to most academicians, was not very good. And more importantly – in life you get compliments that you like. Well, one of the big compliments to me was from the citizens out there: "well you don't seem like a university professor." What does that tell you? What do they think about professors? No, I don't want to seem like an egghead PhD, "I'm right, you're wrong," operation. I try to work with these people. I have more experience, I have more – whatever, in the field of limnology, but they also have insights. And so I started working more and more with the folks.

In my interview, my seminar was very much, "here's where the theory of nutrient loading was going, here is the modeling that we're doing, and here's how reliable the models are, they have big confidence intervals, 30 to 300 percent predictabilities." And that you have to think about the water body, not just what the numbers coming out of that model. What does it mean relative to plants, fish, people? I brought in the people a lot. And that's what they saw, that I was the one that was doing the very applied stuff, theoretical to applied, trying to get real world answers that can help us solve problems. And that's what the two faculty supporters liked.

The ones who were opposed to hiring me thought I was too blunt. That, and they didn't – let's see, it was, "where's your hypothesis? Where's your experimental design? Where's your application?" Because I was dealing with lots of lakes from all over the country, I analyzed the US-EPA's natural eutrophication survey data. And they went, "well, that's not experimental design." They wanted experimental type stuff. And I was working off of empirical analyses, so they didn't like empirical science. And, a whole host of things. Too long to remember anymore. And they didn't like the people part. And then in reality, you look at natural resource people – the students that come in, the faculty that come in – basically, they want to be out in the wilderness by themselves, studying mother nature. They really don't like people. If they liked people, they'd be lawyers, or psychologists, or be legislators. So they get into science, and they say they like people, but they really don't like people that much. And so your faculty get the same way.

And certainly, as you go on in your career, and they basically say, pre-tenure, they'd like to see you involved in national/international societies. So Dan Canfield comes up for tenure promotion, and I was good, because I was President of the North American Lake Management Society, NALMS. Sounds good, doesn't it? Well how the hell did I get to be

President of NALMS? They were $90,000 in the hole. They were going bankrupt. And people that knew me said, “hey, he can solve this problem, he knows how to do things, because he’s a bull in a china shop and doesn’t care what everyone thinks about him.” So I got elected, and I had to go in, and I fired our consultants, I moved the office from Washington to Florida, I brought our people into it, we saved money, we ran a big conference. When I got out of my operation, they were $250,000 in the black. Ok, well, I’m a doer. But, you know, when people think, “oh, you’re President of an international society,” they had their own image in academia. And I go, “whoa, wait a minute, you don’t remember.” Well they don’t.

And I see tenure promotion issues here. I do strange things. Like I said I grew up in New England, firm believer in individual rights. So I’ll give you an example of something you’ll encounter someday maybe. We have at the University of Florida, female faculty. Why? Because we believe we should hire females. That’s what they tell us. Ok, now I’m gonna be your chauvinist pig. I don’t think we should hire any females – ooooooh. Well up comes tenure promotion. Well somewhere along the line, the lady faculty has a child, the child develops medical problems, or the mom develops medical problems, and it delays her production of publications, let’s say. Well they all vote to not give her tenure. And I end up writing the office of the VP and the President immediately, saying, “what in hell are you doing here?” You know, “you go through birth and kids, and then decide to ask someone who goes to work with kids, why they didn’t get six publications per year? *You* couldn’t do it.” And I’ll fight for their rights to get tenure. And so I’m a very strong believer in individuals. And that tends to get me in a lot of trouble, but she got tenure.

And one of the things that aggravates me about faculty is, we should do interdisciplinary science. Ok, fine, “work together.” No – they won’t work together. They’ve developed their own little silos, so as long as they get money, you’re fine, but you have very few people that can really work together. Right now, Michigan State probably is one group that’s working together, up there in landscape limnology. But typically, faculty are in their own little office, and that’s what they do, and they never communicate with anyone. And to go outside of the university and tell someone, “hey, we don’t know what we’re saying,” they don’t like that at all. So, the two faculty that supported me, they were very much into applied work in the state, trying to solve problems. But working with the people out there, it was easier at a Land Grant school, because the issue was working with the community. So I had at least the leadership at that point in time who understood what we’re doing. They didn’t like it, but they understood it. But then the money started coming in. And once money comes in, then they like it.

NALMS has been a pretty good supporter of volunteer monitoring, because you have people like Jeff Schloss at New Hampshire, you have Linda Green over at Rhode Island, Ginny Garrision in Vermont, the main guys. Linda was very much into citizen monitoring. Wisconsin came on board, and with a little support, Dr. Bob Carlson of Kent State

University got the Secchi Disk Dip-In going, but EPA – which is where a lot of the money came from – was not into volunteers They were into, “well, let’s go with consulting firms, let’s go with professionals,” and so I worked very hard to develop the citizen component at NALMS. But now it’s stripped away over time – different people get in, and they’ve become more of a professional organization, rather than deal with the citizens, although they still do. But they’re pickled on this issue, because they like the citizens, but they want to be professional, and so you go back and forth. But pretty much it’s still a grass roots organization. And they are supportive of volunteers.

I won’t say that NALMS grew out of volunteer monitoring, but it was not academicians developing it. It came pretty much from state agency types that were involved in local communities, saying we need to bring lake management to bear. And then some of us in the academic communities became involved in it, because we saw lake management as a big issue. And the limnology and oceanography society, they didn’t want to deal with working with people, or working with consulting firms, or – so, it was a hodge-podge. But NALMS came about because in 1980s, the whole issue about lakes was gonna be a hot button issue, and there’s really no one talking about the management aspects of it. It was sort of a coalition, there were a whole lot of groups there, and then NALMS tried to develop state chapters. Some of the state chapters were very much homeowner groups, others were professionals, and this has been the yin and yang of the society. You know, do you bring in all the homeowner groups and make a bigger society, or do you just have a big professional-type meeting all the time? Which the citizens come to, but they can’t understand what everyone is saying because they use big scientific words. I was promoting more of the citizen stuff at that time. But, I couldn’t promote that very well, because they were going broke. So my whole goal was figure out how to save money and cut back, and bring them back into the black. I won a Secchi Disk Award for my work with NALMS – it’s the award that NALMS gives out to people that have done the most for the society. I’d done a lot for the society over time.

As of this fall, I have now resigned from NALMS. And the reason for that is – their editorial board of the scientific journal they put out has gotten more and more into, “well, we want to put out papers that we like, if they’re controversial papers, we’re not gonna put them out, because of the damage to our image.” When NALMS was formed, a lot of us in the scientific community were very much into that society because they had promised that, “if there’s a real issue, we’ll put both sides out there, not try to direct the thought process.” But with this numeric nutrient criteria stuff around the country, they’re trying to direct it, and saying, “oh, USEPA is right, everyone’s wrong, blah, blah, blah.” And obviously in Florida we thought the EPA was wrong. And so we’re publishing papers, and they kept sending out to reviewers that were heavily involved on the EPA side. So things weren’t getting published. And I had a big fight with them at the Washington State meeting, and they said, “oh, scientific review, we’re gonna honor the peer review process.” And I said, “no, there’s times when the editors have to look beyond the peer review, and publish the paper and then publish the rebuttals." And when they said they didn't wanna do that, I resigned. So now they're all mad because I left the society. But again, that's another issue – I want fair debates, to put everything on the table, you know, don't try to direct people's thoughts.

In terms of connections between lake management and volunteer monitoring, you have some good, bad, and who knows. Again, there are people that, if you're in a situation – a state with no money – they go to the volunteers because they know they need the information. If there's a lot of money involved, the professional agencies look at it as a PR thing, rather than collecting real data. "Oh, we're gonna pat them on the head and say how nice you are," and go about doing their own thing, developing their own programs. Government agencies want to get bigger and better. Not better, but bigger, spend more money. And the citizens tend to be, "let's put the money to solve the problem." And so, in some states it works very well, and other states it doesn't work so well. In Florida, as you might have gathered already from my standpoint, LAKEWATCH is now recognized. DEP now wants their help, but they didn't support developing it, because in the '80s, we started getting rich, and they were trying to develop their own programs with their own lake surveys. It's only now that government's being cut back dramatically in the state that they're saying, "hey, we've got no data without you guys." So, I don't have a real good answer for it. It's very independent, and my guess is it depends on the people involved. Some of us get along well, some of us don't.

Our academicians need to understand how people can help them more. And I'd really like to see Extension adopt this a whole lot more. But we'll have to see where that goes. And certainly in Vermont, or New Hampshire and Rhode Island are keys. But it's a nature of – there are things we can collect that would be scientifically valid, but we need a little more money put into these things to help out. And it'd be a lot less money than having professionals do it on one or two lakes. But having them get us the base limnological information would be very critical.

In the future, I think that the big issue is going to be, "are the lakes changing?" Water quality-wise, there's a lot of saying how bad things are – again, my perception is things are a lot better than they used to be when we dumped raw sewage in, but now everyone's saying, "growth has done this, done that," and I think the data's going to come about, from a lot of different groups as they combine around the country, that, "hey, the majority of the lakes are doing fine." And it's only a few things, so we begin to target things, and I think with the volunteer monitoring, NSF now is talking about citizen scientists, because they realized, "we're gonna have to reach out to these people, get these long-term databases, as scientists we need them." With government, you work on them a little bit, then they end the money, and you stop. So we don't have good long-term databases. And I think NSF promoting citizen scientists now, is probably getting the people in academia to say, "hey, we need to work with them," I hope, by now. That's sorta where I see it going. I see LAKEWATCH, here in Florida, it's gonna be taking on much more of a role that, when we have lakes that are problems, the legislators are looking at us as open-minded to say, "ok, what should be done to resolve the problem?" I think they're looking at us more and more.

Caren Cooper

Cornell Lab of Ornithology

Cumulative impacts

Officially, Caren's relationship to citizen science is as an ecologist making use of large-scale datasets. I initially spoke with her to learn how, more or less in her spare time, she also managed to start her own project, My Yard Counts. Through our conversations, I learned that her experiences with citizen science were much more diverse than I had known, from her early experience as an undergraduate field assistant with an Earthwatch project, to recent work taking a social science approach to understanding volunteers. Although her work with My Yard Counts ended when the project transitioned to a different format, her inspiration to ask new questions both through and about citizen science remained undaunted. For example, I spoke with her three times over the span of January 2009 through October of 2011, and thus she refers here to several rounds of submitting the same proposal to lead new work engaging volunteers. Unlike most of the other researchers I spoke with, Caren's entire career is beholden to working with citizen science datasets, and she fully and passionately explores here both the challenges and potentials that this research approach offers her. As a close colleague who I see regularly, Caren shared her story in a very personal and forthcoming way.

I call the work I do kind of a backwards scientific method. Instead of having a question, which is the way that some people might use these resources – they might have a question, this whole big research agenda that they're working on, and a question arises that the citizen science dataset might be good to answer. But instead, my job is supposed to be to publish and make use of these datasets. I see what's there, and I say, "ok, well, what questions would be good? What questions are worthwhile looking at that we could actually use these data to answer?" Which usually involves patterns we don't know enough about. Or it could even, given what we know from small-scale studies, construct some hypotheses about what we would expect the large-scale patterns to be, and then see if they're there.

The project I was involved the most with was The Birdhouse Network[1], because when I came to the Lab of Ornithology that was the one that no one was really working on. It was set up to answer questions about geographic trends in reproductive parameters, and so those are the kinds of questions I started using that data set for[2]. And then I've

[1] Now NestWatch, http://nestwatch.org/

[2] Cooper, C. B., W. M. Hochachka, and A. A. Dhondt. 2005b. Latitudinal trends in within-year reoccupation of nest boxes and their implications. Journal of Avian Biology **36**:31-39.

tried to use the other citizen science data sets at the Lab as well. That includes Nest Record Cards, which complemented The Birdhouse Network, and I did use those in a paper[3]. I've used Project FeederWatch[4] data a little bit in a paper on competition[5], and I have tried to use PigeonWatch data, but couldn't get anything out of it. I've also started my own project that went a few years, called My Yard Counts, which used a combination of eBird data and data collected through SurveyMonkey, and then also there was finally an online application to get dead bird data. That one hasn't been published yet, but hopefully will be soon[6]. And I have a paper in the works using data from the NestCams on laying intervals. I think those are the different… oh, with the FeederWatch paper that I published, I also used Christmas Bird Counts and Breeding Bird Surveys. Basically I've been trying to use every citizen science bird database, but I haven't yet used them all.

My role has been to take the lead authorship on publishing papers using those datasets. But there hasn't been a unified topic, that's one of the hardest things about it. So for any paper, I mean, like I researched a lot about life history traits related to reproduction so I could write some papers on geographic variation in life histories. Then, when it came to doing FeederWatch, and it seemed like competition was something to write about, I had to read and get up to speed on this whole other topic. And if I do the My Yard Counts stuff it's all about cat predation and I have to get up to speed on urban ecology and cat predation. So they all come with… they're not centralized around a certain theme necessarily, except maybe large-scale patterns. It's not the typical way someone would structure their research career.

When I was an undergraduate, after the end of my freshman year at North Carolina State University, there were two internships within the department for the summer, and I applied to work on those. One was with Red Cockaded Woodpeckers, and that teacher eventually became my PhD advisor at Virginia Tech. But they didn't hire me. Instead I was hired to work with black bears, which was actually *so* much for the better, it turns out. So for that summer and the next summer, and then later on in my junior and senior years, I worked with the black bears in the mountains of North Carolina. It was an Earthwatch project, so we had Earthwatch volunteers helping us check the trap lines. We trapped bears and then radio tracked them, and every morning… we had a whole bunch

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Cooper, C. B., W. M. Hochachka, T. B. Phillips, and A. A. Dhondt. 2006. Geographical and seasonal gradients in hatching failure in Eastern Bluebirds *Sialia sialis* reinforce clutch size trends. Ibis **148**:221-230.

[3] Cooper, C. B., W. M. Hochachka, G. Butcher, and A. A. Dhondt. 2005a. Seasonal and Latitudinal Trends in Clutch Size: Thermal Constraints During Laying and Incubation. Ecology **86**:2018-2031.

[4] http://feederwatch.org/

[5] Cooper, C. B., W. M. Hochachka, and A. A. Dhondt. 2007. Contrasting natural experiments confirm competition between house finches and house sparrows. Ecology **88**:864-870.

[6] Now published: Cooper, C., K. Loyd, T. Murante, M. Savoca, and J. Dickinson. 2012. Natural History Traits Associated with Detecting Mortality Within Residential Bird Communities: Can Citizen Science Provide Insights? Environmental Management **50**:11-20.

of trap lines. Basically it involved hiking 5, 10 miles, I don't even remember, but we'd hike all morning and check the traps, and if they got disturbed we'd reset them and rebait them. Or if there was a bear we'd hike back, tell everybody, and then the afternoon would be spent processing that bear, putting radio collars on and stuff. And then around the clock we had different shifts for radio telemetry, tracking where the bears were.

I did this after my freshman year and then after my sophomore year. After my sophomore year I went and took a different job, just for variety, but it was as a hack site attendant with peregrine falcons, so it ended early, it was a very short season. I stopped by to visit the bear project and the intern they had that year had just quit, so they said, "oh my god, would you stay?" So I ended up having a second season, which was great. And then I did some winter work and then came back after I graduated and did a summer/fall kind of thing, but in the fall we didn't have Earthwatchers. So I worked with that project for a while. It was a long-term study – in fact, the professor just retired, and I don't know if anyone took it over. It wasn't Earthwatch the whole time. I think those were mainly the core years, the ones when I was there, because it was a lot just to find the right people. Like, it definitely helped when we had a cook. Just because it was a lot to manage and it was a lot for grad students to handle.

The Earthwatchers… it was a huge crew. It was probably around 10 to 15 – it was manageable. I think there's just something about having a big crew in the field. Because everyone's focused on the same goals, you know, and you're camping, and… there's just more camaraderie, I think it was mostly that that I liked about it. And people were always really curious about me, because I was the youngest. It was like, "what is she? She's not one of us, but she's so young, and she knows what she's…," because I knew that project inside and out, pretty quickly. And we camped, so we had all our meals together. I think it was mostly the camaraderie, I liked the large field crews. And it was just nice, too, the way they had this whole spectrum of ages, people at different stages of their life. You know, there were old hippies, and young girls trying to figure out who they were. And there was always a soap opera [laughing]! When you get a group of people together in a field situation, it's always interesting. I guess the science was kind of the backdrop to a lot of that, actually.

With Roger Powell, the faculty scientist, people would mostly talk with him informally. There were always questions, but he didn't have any formal structure to teach them about the bears. There was always discussion. And there was a grad student or two, sometimes three, that were on the project also. But people didn't know, like… you know how it is, outside the Lab in regular academia no one really even talks about the value of informal science education. There's all these benefits to people, this opportunity to teach, but nobody thinks of it that way. It was like, "here's our volunteer crew, what's the minimum we have to do to make them happy, and have a good experience?" I think a lot of times that was the attitude. "If they're not happy with peanut butter and jelly every day…" [laughing]. It was like, "oh my god, we have to take them into town to do laundry, *fine*…."

But the volunteers would loan their skills. One of them I remember was a computer programmer and she ended up making a data entry interface for us, to enter a lot of the information when we were radio tracking. And so they would get involved. Now that I look back on it, they did get involved with whatever expertise they had. And then for some of them it was like vacation, they could go home and tell people about. Some of them were serial Earthwatchers, and had done other projects, and that was always interesting, because then they would compare, you know. "Well, with the Przewalski horses, we got to live in a castle!" You know, and, "we had gourmet food, you know…" [laughing], whatever!

I don't think I knew about the volunteer aspect when I applied for that job. There was no special prep. But there wasn't even for doing the bears, just learn when you get there. But it was a really good program. Oh, we did do some stuff with the Earthwatchers, that I think the grad students led. We had an orientation every time a crew arrived. We'd have a big picnic, and we'd play Frisbee, and we would do those trust games, so you know, like you'd fall back, and we'd have them on this huge stump falling back [laughing]! So we did a whole bunch of group bonding things, and then divided people up into tents. But I think that was more the initiative, depending on which grad student was there and how that went. Some of those Earthwatchers I kept in touch with for years.

When I took the job at the Lab of Ornithology, my job was explicitly for citizen science. I came here in 2001, shortly after I had finished my dissertation. The structure of the Lab was different then. Rick Bonney had just split off to be head of Education and Ron Rorbaugh had started being head of Citizen Science, but his was more of an administrative role, rather than a researcher. And so André [Dhondt], when he hired me, his department, Bird Population Studies, was taking on the role of using the citizen science data, and he and Wes [Hochachka] were using FeederWatch, and the House Finch Disease stuff was just starting up. And André wanted one more researcher specifically to publish and utilize citizen science, because… because that's what they tell people, is that it's collected for science. I don't like to say it that way, because that's a negative way… the positive way to say it would be, because there are so many interesting large scale questions we can look at [laughing], but in reality it was really just that we were collecting these data, these projects have grown up, and nobody was actually putting them to use, which was what we had promised would be what would happen to them.

And obviously the Lab attracted me to the position, because that's like the Mecca, so that was a big deal. And also that it was just a research position. I didn't feel ready for a faculty position, so being a junior research position was good. And I *totally* had data envy, because when I did my dissertation – I was at Virginia Tech with Jeff Walters, my advisor, and he studies Red Cockaded Woodpeckers and has two decades worth of data, so all the other grad students in his lab had this huge data source available to them. They were looking at, you know, pedigrees, genetics, literally just from plain breeding records going back decades. And they would look at so many things… dispersal, whatever. I went to Australia and collected my own data, and got like 14 dispersal events [laughing]. I was always really envious of these big datasets, so that was the other thing that attracted me to the citizen science position. I had done some simulation modeling which made big datasets, and that's how I argued that I could handle big datasets, because I had done these simulation models. I definitely wanted big data, I thought I could do anything with it [laughing]. I didn't realize how hard it was [laughing], in terms of both data management and organization… even just mentally. And also in that it's such coarse data. It's just not the same level of detail as what Jeff had, as one scientist. Even though it was several study sites, he had intensive paid technicians who were banding, and weighing, and recording every detail. It's the whole fine-scale resolution, compared to just people seeing things. So, the inferences you can make from citizen science data are really different.

I guess I thought citizen science would be powerful because of the datasets being so big. When I came here, I think the general feeling was that citizen science data were hard to publish because reviewers didn't like the quality of the data and didn't trust it. But that was mostly focused on bird observations, like FeederWatch, as opposed to what I was doing with the reproductive data. I didn't think anybody was going to doubt that if someone said there were five eggs there were five eggs, it's not like they're mistaking a purple finch and a house finch or something. I did understand that the Lab wanted to build up the reputation of citizen science. One of the first papers that I did submit, the subject editor liked it a lot, but the reviewers hated the data. And so the editor called me on the phone – I guess this is uncommon – and he said, "I suggest you rewrite it as a concept paper, where the ideas of what you're saying are the main focus, and you just use a little bit of citizen science data to back it up," rather than the way I initially wrote it, which was that I wrote it like a traditional paper, "here's the data, here's what it means." And so I did, I rewrote it that way, and published it that way[7]. So there's been this general feeling that we have to make citizen science data reputable. Which is kind of weird, given that with Christmas Bird Count data, and the Breeding Bird Survey data, there have been tons of papers on those things. So I don't know why we have so much trouble with ours [laughing].

It was shortly after I got here that I realized how hard it was to organize and manage the data. And, I don't fully know what makes it so tough, other than that somehow, conceptually, maybe because it has so many variables that you've got to reduce. It just is

[7] Cooper, C. B., W. M. Hochachka, G. Butcher, and A. A. Dhondt. 2005a. Seasonal and Latitudinal Trends in Clutch Size: Thermal Constraints During Laying and Incubation. Ecology **86**:2018-2031.

always harder. We always sit down to plan papers and think, "oh, it'll be easy, we're just going to look at this and this, we're going to test this hypothesis, or we're going to…." It seems like it will be easy, and then when we sit down and do it, it's like, "oh my gosh, ok…." We've got to make decisions along the whole way. Like with FeederWatch – oh my god, I hate that dataset. Which months are we going to include? How are we going to collapse all these observations into one description of that location? And which other datasets are we going to bring in, which land cover, which this, which that? It's kind of the same in landscape ecology, because you can make a zillion variables to describe the landscape, and you just don't know what variables are the important ones. It's like that, but magnified. So I feel like regular researchers get to like run along at this fast pace, and I feel like we're shackled, we're in a little sack, hopping, and trying to keep up, and it goes so slow.

And I have yet to really pinpoint what it really is. I keep thinking, "oh, if I just structure it differently, if I make my hypotheses more clear, if I make the test so well defined, it's just going to be easier." But, even just the thought…. I deal with The Birdhouse Network data all the time, but even the thought right now of, if I had to go to my computer and pull a bunch of Birdhouse Network data, I know right there that's at least two or three days of just getting back into the code, and figuring out how I'm going to extract the data. It's mentally exhausting, to plan that out. I don't know how else to describe it. And now that we have NestWatch – and I was involved in making that new data structure, which was sort of to mimic the Nest Record Cards, and I've dealt with Nest Record Cards, so it should be easy, but I can *not* use the data yet. I have to have help from a programmer to get the data into the format that I need. It's beyond my programming abilities. Looking at that data is really, really hard.

If it was a small data set, it would be nothing. For example, David Bonter and I had run this trail out here with these chickadee snags, just this little, minor experiment. So last Christmas [2007], I was like, "I'll just write that up." It took me literally about a week and a half. To get the dataset ready, type it into Excel, get it into SASS, run the analyses, write the paper, and it was done, it was accepted three weeks later[8]. I mean, it was like that [snaps]. I was like, "wow, I really do know how to do research." It's totally somehow the size of the dataset and the difficulty, they just get exponentially more and more difficult. And believe me, I really wish I could understand why… I don't know fully know.

I have felt for a while like it's difficult. Wes and I have talked about that some. And he has been saying, "yes, it is harder." And actually now that Ben [Zuckerberg] is here, he finally told me also that he's surprised at how hard it is, dealing with the data, with large data sets. And I was so relieved. I mean, I can't even describe my relief, because I came in

[8] Cooper, C. and D. Bonter. 2008. Artificial nest site preferences of Black-capped Chickadees. Journal of Field Ornithology **79**:193-197.

here, really just having done my dissertation – and I did a really good job with that, I got five papers and a book chapter out in one year, in 2002, so I felt like, "alright, I know how to do research." And then I came here, and it goes so much slower, like every paper took forever to get through, and the analyses took forever. It was like constantly working with these data. Some say it's because when you're not the one collecting it you don't have an intuitive feel for what's going on, but when you're in the field doing it, you have a really good sense. Which is why students always know their projects better than their advisors ever do, because they're the ones who are really so intimate with it. And with these big data sets you can do as many graphs as you want, and histograms, but you're really never going to get quite as familiar with it because you weren't there, really experiencing it.

Lately I've dealt with all this by not doing it. I've been trying to do my own research. When I started with the Birdhouse Network data, a friend had told me about those little i-buttons, these little dataloggers. No one had really been using them yet, so I made a proposal to André that I could send these to participants and they could put them in nests, and I showed him how you can see incubation behaviors. And he thought it was great, he was ecstatic, and so we started doing that. And then it became a problem of… ok, so this was one of the first lessons I learned in citizen science, was you can collect so much data that you don't even know what to do with it. With these little automated data loggers, suddenly people were sending me back data, and it was *way* more than I could ever process by hand. And so, I was like, "oh my god." André was like, "yeah, I should have mentioned that lesson." So that's when I collaborated with people downstairs in Bioacoustics to adapt RAVEN, the bio-acoustic software for looking at sound waves, to look at incubation rhythms. It's helped. Actually, Harold was in this morning because he just gave a new version to me, and hopefully that will really help. It seems like its come along enough, and I've trained students to use it. But I still haven't published from my incubation data. I tried once, and it wasn't sufficient, so now I'm hoping to do that. I'm hoping this one student can really help us get the data reduced. And it's just a data management issue, pure and simple. The ideas behind it have been there for ages, since the beginning. Conceptually it's all really good, both in terms of the geographic variation in the onset of incubation and then how the birds incubate, once their clutch is complete. But reducing the data and getting it into a form that we can use it has been insurmountable.

The House Finch Disease Survey has published the most I think out of any project. Actually, I don't know if that's true. The House Finch Disease Study has published the most, but only a portion of that has used the citizen science data[9]. And I never really

[9] See: Hochachka, W. M. and A. A. Dhondt. 2000. Density-dependent decline of host abundance resulting from a new infectious disease. Proceedings of the National Academy of Sciences **97**:5303-5306.

looked that carefully to see how many papers actually used that citizen science data set to describe the spread. But that's the basis of all their models and stuff, too, and it certainly is the basis of all their experiments and captive studies to understand the dynamics of it. So, it's basically spawned the most research. And it was totally serendipity, that they happened to have FeederWatch in place, and that this disease spread, and that the disease was something that manifest as a big swollen eye that people could see in a really common bird. I mean, you couldn't ask for a better system. But they did a really good job of setting up the protocols so that they could track things appropriately.

FeederWatch alone hasn't done too much, actually, I mean, there's been stuff with redpolls irrupting and those kinds of patterns. I think there's about to be a lot from what David is doing with Ben on the expansion of Collared Doves[10], and… I'm not even sure what all they're working on. They had that one competition study with house finches and house sparrows. But that's really it, as far as I know. It's not like I can say, "oh, well, there's this big paradigm shift, because we discovered such and such a pattern, and it changed the way everybody thinks about such and such." I hope one day we will be able to say that. But right now, I can't say that. I mean, I think they can say that about disease, but I'm not involved in that research at all, so I don't know. But I think they actually have found stuff with that disease that was not expected.

From The Birdhouse Network[11] project we did learn just a little bit about some of the patterns, some of which were obvious, like that the number of nest attempts decreases as you go north, while the clutch size gets bigger. The incubation period changed – I'm not going to be able to recount this in my head, but we think it might be related to temperature, in terms of when birds begin incubating and how short they can make their incubation period. But it might be that there are just intrinsic differences in the growth rates of the embryos, or it could be that the birds incubate differently. That's what I'm trying to figure out. And hatching failure is much higher in the south, and late in the season. There are basically these latitudinal trends, and seasonal trends. And if temperature and photoperiod are drivers of those, it kind of makes sense, because they sort of mirror that, you know, because everything becomes like the south late in the summer, right? So, I don't know.

I do think that there has been a change in the way people think about this, although I don't know that I can point to anything tangible. I know that Ben was just saying that just

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Hartup, B. K., J. M. Bickal, A. A. Dhondt, D. H. Ley, and G. V. Kollias. 2001a. Dynamics of Conjunctivitis and *Mycoplasma gallisepticum* Infections in House Finches. The Auk **118**:327-333.
Hartup, B. K., A. A. Dhondt, K. V. Sydenstricker, W. M. Hochachka, and G. V. Kollias. 2001b. Host range and dynamics of mycoplasmal conjunctivitis among birds in North America. J Wildl Dis **37**:72-81.

[10] Now published: Bonter, D. N., Zuckerberg, B., & Dickinson, J. L. (2010). Invasive birds in a novel landscape: habitat associations and effects on established species. *Ecography*, *33*(3), 494-502.

[11] Now called NestWatch.

this year [2009] there's a whole slew of papers out that are comparing citizen-collected data with non-citizen data that overlaps, and they're finding that it's fine, for trends – like if the citizen science data is detecting a decline in some species, the regular surveys, professional surveys are detecting it too, so that they're matching. That's a really big boost, to see that. It just seems like it's becoming more… that there are more citizen science projects. I don't know why I have that impression. It could just be the way it is here, that citizen science here has gotten more attention, you know, with the new Director and the whole Department. And at the Toolkit Conference[12], there were all those different projects, although I didn't get a sense that that many of them were research-driven projects. There's a lot of ways to involve people in collecting data, and in different parts of the scientific method, but then to actually make it be useful to research, I don't know… I mean, I feel like at the Lab we try to be really vigilant about trying to do that, and it's hard.

And I want to stay at the Lab, so I need my research to fit in. And for that reason I need to always be trying to leverage the citizen science data sets. But I also need something to characterize what I do. I want my research to help understand large geographic – or especially latitudinal – trends in natural history traits in birds. From the equator to the poles, there are a lot of these trends, and there are more of them than I realized. I'd always really been focused on clutch size. And then I thought I was getting really broad because I was interested in clutch size and number of clutches. But now, with some recent work that I've been doing looking at body size – because there are these body size gradients – there's also gradients in metabolic rate. There are whole fields of study about this that I didn't even know about until recently. And so I focus mostly on incubation. And it's a very energetically intensive thing, and so it's very tied to metabolic rate, so it's also very tied to body size. I'm trying to integrate across these fields, fields that have been looking at macro-ecological processes, that have been looking at metabolic rate and body size relationships, and these latitudinal trends.

And I focus on photoperiod. It's really weird, but for these trends people have looked at temperature, because there's an obvious temperature gradient with latitude. And they've looked at biotic parts of the ecosystem, like predation rates, which people say vary with latitude, disease, which they say varies with latitude, and food supply, which varies with latitude. And it's just weird to me, almost, when I read these, that no one's actually looked at the influence of photoperiod. I guess because it's so correlated with latitude, it's kind of difficult. So I'm trying to tease apart from the literature stuff that is…. See, there are also altitudinal gradients and longitudinal gradients, and I'm trying to look at those gradients because the latitude is the same, you can compare across latitude and still see these gradients. I'm trying to focus on those kinds of questions. And I think I'll

[12] 2007 Citizen Science Toolkit Conference, held at the Cornell Lab of Ornithology to compile best practices for science and education through citizen science.

always be trying to leverage the reproductive data sets at the Lab, because I guess that's become my niche here.

But I'm sort of at a crossroads, career-wise. This is the year [2009] I'm supposed to be setting what my research agenda is. It's in a state of flux… if I had the answer to that I'd be more set [laughing]. I intend to keep using the NestWatch data sets, and hopefully the historic ones. There are a lot of questions that I think I could get at the answers by looking at historic trends and the geographic variation, but I haven't yet put them all into a unified context. That's been part of my problem, is seeing…. I think that was one of the things why I was disappointed in the Toolkit Conference, because at the time back then when we did that, I was under this belief that citizen science could have these unifying research themes that were perfect for citizen science. And I kind of don't think it anymore. I mean, it would have been really nice if it had been that way, if it were that way. I thought that macroecology – you know, large scale patterns – that somehow that field could be advanced by the citizen science method, and they'd be like one and the same. Like someone would think, "yeah, I'm going to be a macroecologist, and so that means I'm going to really use the citizen science method, to no end." I thought that was going to come out of it, in those research meetings. I really thought in my head that we could identify these cutting-edge types of questions where we could advance the fields. But it seemed like no, actually, that wasn't the case [laughing]. I don't think that anymore because whatever questions I come up with, it seems like, oh, well actually, it would be better to just collaborate with professionals, and get really detailed data at like three different field sites, and say that's geographic variation, rather than these coarse data that spread across the whole entire gradient. It always seems like there's an easier way [laughing] than actually doing it through citizen science. And, that might not really be the case, but I… I just haven't found it. I think I had already sort of figured that, but then being disappointed in the Toolkit conference made me accept it.

So for the sake of having my own research agenda, which seems essential at this stage in my career, I've still been focusing on geographic variation in reproductive ecology, but in getting it through other means. Getting those data through collaborations with real – with professional scientists, rather than just relying on citizen scientists. So I have some papers that way[13]. But it's still the same topic, and in a way it's just helped me get better versed in that whole macroecology literature, and hopefully I'll again see how I can leverage the citizen science data to address some of those gaps.

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[13] Cooper, C. B., M. A. Voss, and B. Zivkovic. 2009. Extended Laying Interval of Ultimate Eggs of the Eastern Bluebird. The Condor **111**:752-755.
Cooper, C. B., M. A. Voss, D. R. Ardia, S. H. Austin, and W. D. Robinson. 2011. Light increases the rate of embryonic development: implications for latitudinal trends in incubation period. Functional Ecology **25**:769-776.
Dor, R., C. B. Cooper, I. J. Lovette, V. Massoni, F. Bulit, M. Liljesthrom, and D. W. Winkler. 2012. Clock gene variation in Tachycineta swallows. Ecology and Evolution **2**:95-105.

For the research I'm planning now, I have a collaborator in Ecuador who can collect all the data that I want, on a bunch of birds. And then, if we ever get money, we have someone in Canada who can go in the sub-Arctic and get data, and we have our temperate data. So we would have our tropical-to-colder data, and we would get it without… it would be really fine scale, at these sites. I'm also on the *Golondrinas* project with Wink [David Winkler], which has study sites with swallows across the whole western hemisphere. With that we're getting really fine-scale data from all these specific study sites. The management is like citizen science, and I'm scared about that, but the level of questions that we potentially can pursue is so much better. I guess I'm waffling on it a little bit.

The data are so much finer-scale because we are getting blood data, and if we want, we could have them do immune responses… we can have them do basically anything we want, because they're paid technicians that are out there just to collect the data that we want. And having it from a discrete number of study sites, along a gradient – or my planned research if I just had it over three sites – it's so much easier, actually, than having it from three hundred sites that are all over the place, because it's so hard to collapse that. There's the longitudinal variation as well as latitude… "I have this, I have that," there's so many factors. I can see why what Daniel [Fink] is doing with his bagged decision trees – his Bayesian statistics, he calls them bagged decision trees. I don't know how he does the stats, but he does these fancy Bayesian statistical things, and I can totally see the appeal because there's so many dimensions to the data, it's more than what we can visualize. So how do you take that and get it so that we can see what patterns are there? The regular statistical techniques are sometimes just not quite sufficient. But, if you just have three little study sites [laughing], I could stick with traditional methods and just compare, you know what I mean? It's just easier than these big old gradients. And I do some fancy stats, but my comfort level can max out pretty soon.

I mean, I was here about four months when I came across mixed models in the literature. And I went to Wes and said, "you know what, for these analyses we need to use mixed models." And he looked at me and said, "wow, it took me four years to realize that." I was like, "yes, I got it right!" [laughing] That became a standard for us, mixed models, but it only gets you so far. Mixed models are good because we have all these different – we have a lot of data from many, many sites. And you want to use all that data, but you have to partition the variance so that it knows that they're all from the same site, because… it's like repeated measures, like if you measure a person a whole bunch of times, and you measure all your subjects a whole bunch of times, you have to control for those repeated measures. So it's the same thing, we have to control for that. But even beyond that, and especially I think with the bird observations – like they use with eBird and with FeederWatch – it just only gets you so far. It's just so multivariate, and so it's not just two dimensional, there are just so many dimensions.

A lot of what they do is still just exploratory – the data miners, Daniel and Wes, and people on campus who are going to try to do hypothesis testing – I guess I don't know that much about what they do, but I know that in some sense it is exploratory. And they have had to do a whole sales pitch on it, because at first, when a traditional ecologist hears what they do... because they call it data mining, which, everyone's taught to never do that, right? You just don't do that. You form your hypotheses first, based on other observations, then you get your data, and then you test it. So, it sounded like heresy, to say, "oh, well, we're going to data mine," like, "oh my god, you're kidding." So I don't think it's a good term for what they do. What they're really doing is basically seeing the patterns that you couldn't see any other way. And they are new patterns. I mean, that is the power of citizen science. It's these huge, large-scale patterns. It's just that it seems different because you have to do stats. Before, you would have said, "I have a microscope now, so I can see all these new things I couldn't see before," and people would be like, "oh, that's cool." You know, or, "now I can see DNA," "I can do this lab technique, and now there's all these patterns I can see." For citizen science data, we have this big microscope called Bayesian statistics, and now we can see these patterns, and start to generate these hypotheses. So it's kind of a weird… I mean, I think it's a good direction they're going, it's just that I can't go there. Me personally, I can't go there. I guess I'm a little bit too much of a traditional ecologist… I'm not a stat head. It's hard taking my traditional training, which is in population dynamics and a little bit of behavior, and then applying it to these situations that are totally different. It's tough.

Career-wise, some people say I need to look at the fact that I don't have to teach. Normally in a faculty position, people would try to cram in as much research as they can, and just do their teaching responsibilities because they have to, and so people say to me, "well, you just have to do your citizen science responsibilities, and then you can do whatever other research you want." I mean, I try to make them complementary, but… that's it. And I try to involve undergraduates. I have very limited contact with campus, but there are undergraduates that like to come out here.

And I am a big believer in involving people. I love all the benefits, supposedly, that happen to people when they participate in citizen science. I like to think that people really benefit in some way, in terms of their connections with birds, with nature, or even with science. Because people don't, I mean, the public in general is so scientifically illiterate, and people are so detached from the natural world, and from things that make them curious. Sometimes I think of it that way, is that citizen science is this little venue for people to go, "wow, I wonder about this," when there's not a lot of places where people do that.

There was a year or two period of time where I was really involved in other aspects of the citizen science projects, when we got the NestWatch grant. I had been involved with

The Birdhouse Network with Tina [Phillips] a little bit, and then we got the grant, and so we had to develop the NestWatch and CamClickr project and all that. I was involved in writing that proposal with Rick Bonney. I liked that it was an area for me to be creative, because … that was Rick's third time writing that grant proposal, and André hadn't in the past let him involve me in it. And I was the one that suggested that we make it a treatment of these three things. Rick kept saying, "we need an online citizen science project," you know, "we need other things, how are we going to frame this?" And I thought, "let's make it be these three treatments, these learning treatments of an online project, a regular one, and a mentored one." And I think that's what helped get it funded. And then he knew he wanted a virtual project, but he didn't know what it would look like. It wasn't until really after we got the grant that I had a big brainstorm – and I don't mean to be just taking credit, but I did [laughing] – I had a big brainstorm, and I sat down with Janis and Tina and I said, "this is what the project can look like," and that was CamClickr. Visually, it doesn't quite look like I had thought, but anyway… And, you know, I came to Janis and Tina, and I said, "oh, here's how we should do CamClickr," you know, and that was the prototype for the way we do CamClickr. I said, "we should have it be a matching and sorting game." And then I wasn't really involved in its development *per se*, but I'm happy that I got to provide the idea that made it happen.

So I was involved in those early days with NestWatch. And they were *painful*. I didn't get any research done, it was just meetings on top of meetings, with database people, and web design, and this and that. And, my role was sort of redundant with Tina's, so eventually I just said I don't need to be there. I had thought that my role might be sort of helping facilitate the citizen science projects in some way, but that really didn't work out. It was very clear that I needed to just focus on research, and so the other stuff was kind of like a waste of time. It was basically like I had spent a year or more doing absolutely nothing toward advancing my career [laughing]. I guess that doesn't sound good for how a scientist is involved in the other aspects of citizen science projects, but I think for most researchers, they're just going to use the data that's available. And that's really all I'm going to do. I'm really not influencing much at all in terms of what data are going to be collected.

For NestWatch, though, we have talked about having these little side projects, once it gets a good foundation. Like, we could have people do an artificial nest experiment. We could make a protocol, we could have people put out artificial nests, and we could have them check them at different rates, and see if there's an effect of sampling intensity or something on predation rates, or, you know, just different stuff. I've had a zillion ideas, such as having people send in their house sparrow eggs, because there's a lot of cool things about egg size, geographically. There are species that you could do anything with, you don't need permits. But, they all involve collecting more data, which seems insane given the amount of data we already get. In the end we've always opted to not do these additional projects, because they result in more data and it's not like we have more people to analyze them. So unless we had a student who was specifically interested in looking at geographic variation in house sparrow egg size, and speckling patterns, then we're not going to do it.

I did find that I could consult with people when they're developing their projects. I also helped Karen Purcell develop CUBS, the Celebrate Urban Birds project, and that also took forever. We must have done a hundred different data forms, because when you write instructions for citizen science participants, it's hard to be clear, but then you also have to be concise. And so we tried using pictures, or this, or that. And it's not like I have training in it, so we're all just reinventing the wheel. It always seemed like there should be someone who creates surveys who we could have just asked, "what's the appropriate wording here?" you know? I mean, we would debate the stupidest things, like, "let's have them do it in terms of two basketball-size courts," or, "no, no, three school buses," you know, even what unit of measurement do you have people judge a distance by? It's just crazy stuff. So that was also, I mean, I hate to say a waste of time, but….

But Karen's thinking was that if she was starting a new citizen science project, she wanted a scientist invested in it from the beginning. Because she felt like that would make it have the highest chance of being a legitimate citizen science project, that's scientifically credible and that's going to produce publications. So she had me, and she had a grad student, Viviana [Ruiz-Gutierrez], and of course Janis. And, it's been a while since I've looked at the data, I should actually see how much is there. It's not even on my radar now, to do it, but I guess we should publish it at some point. But it'll be a bear to do, I have no doubt.

I guess my lesson that I learned through working so closely on these aspects of projects was that I can see why André isolates himself in the corner [laughing] and just does his research, because when you venture out, and try to do a little more, it either draws you in so that you don't have time to do the research – it does, and then there's no point in that having happened, because I don't think it even changes anything [laughing]. I mean, it doesn't get you anything that a simple consultation couldn't have handled. Like when Steve [Kelling] developed eBird, his first version of it, he didn't ask anything about effort, or about if they were recording all the birds in the checklist or not. And then he just consulted with people, and they said, "well, you know what, you need to ask if that's a complete checklist of everything they saw, or not, because that would be really important for us to know." So he added the variable. It makes a world of difference, it's one variable, and it changes everything, because, you have to know that to make the data useful at all.

For CUBS, it might have mattered a little bit that I was involved at the outset. We made this protocol for CUBS, but we never even did it ourselves. It wasn't like I was a scientist working in urban ecology, collecting these data, or collecting similar data, and out there in the field, and really familiar with what was going on, and then thought, "ok, let's morph this a little bit, so that it could be used by participants." Because then I think that probably would have worked. And that's essentially what happened with The Birdhouse Network, I mean, all of us have monitored nests, and so we can think, "ok, well, we do know what it's like to monitor nests, and we're going to kind of morph that, and make it be something that people do." So it could have worked differently with Celebrate Urban Birds, if we would have just had the time to even spend a field season, and been able to say, "let's just do this ourselves as our own project, and then morph it." But it's always this rush, like, "no, we have to do it *now*," for whatever reason. And so it's these things that we have with our citizen science projects, you know, they start for education reasons, or outreach, they're not necessarily started for a scientific objective, and so that has to be jury-rigged in there later. Which is why sometimes I think it's just better to just see what the data are, and either they're going to be useful, or not.

Actually, the Cam data that Tina has been collecting, I never thought it would be useful. But, now I have this paper and I was so glad she had it, because no one has information on the time of day that birds lay their eggs, and it turned out that I stumbled across some research where knowing that would be really interesting for wild birds. So I was able to go to the Cams, and pull that out, and thought, "wow, it's really great we have these Cams." I had no idea.

People always say about citizen science – André has said it a lot, too – that these big data sets, in some ways you don't even know their potential at the onset, and you might not know it for a while. There is this hidden benefit to these projects, which we might not see pay off for a long time. Like the Nest Record Cards, now in hindsight it's so great people were collecting those data, but it's not like when they collected them they thought, "oh, you know what, there's going to be some big environmental problems in the future [laughing], and it's going to really be good to have this historic record." They do have this hidden potential. There's definitely something really good about… I mean, it's kind of like history – I guess natural history, here. People record history, and it has a value, you just don't always know what it is, but there's stuff to learn from it. And because you don't know what it is, it's hard to anticipate exactly how it should be collected, and what information. We do have some basic rules of thumb, which are implemented in our projects here, in terms of recording effort, and replication, and stuff like that. But the Nest Record Cards, their benefit might not pay off until we finally digitize them, and learn some amazing things about global warming. They are getting more long-term data, which is an expense. I think to do a short term study you could maybe do it fairly cheap with a few technicians, but to have these long term data sets build and accumulate – the longer term they go, I do think the more valuable they become. I suspect that as you go more long term that they're worth more, and that maybe they're cheaper, but I don't know.

It's really hard for me to remember all the details, but when I started My Yard Counts I was interested in what was happening around peoples' residences, in terms of birds. I guess somehow I realized that citizen science was an untapped potential. I remember reading... in the Partners in Flight document that Ken [Rosenberg] had published, he listed threats to birds, and one of them was what he called dispersed mortality factors. It turns out he meant things like power lines and wind turbines, but I was thinking about it on a finer scale, in terms of window crashes and house cats. Or, maybe I had read a paper, where somebody had done some work with cat predation. Anyway, I realized that citizen science was the ideal venue for studying these things, because you have to have landowner participation, and they're all conservationists, at heart. I don't remember how it came about, except that André told me not to do it [laughs]. He never liked the research topic. So that first year I kind of went a little teensie bit behind his back and I did it with Tina. He only kind of said no, he said, "you collaborate with Tina," so I said "ok." I said to Tina, "I want to study birds around yards" [laughing]. And she said, "ok!" She was game for anything. And then Janis came on, and so then I was partly in Janis's department, and… so, then she said, "oh, yeah, ok you can do it." So I was like, "awesome, yes, it's totally what I thought would be great."

When it started, it was really about birds around residences. I don't remember if I had an interest in the dead birds right away, or if that came when I changed the name to My Yard Counts. It first started as… it was called Yard something. I don't remember what it was called. Basically I wanted to survey people about the birds around their yard. So we developed a survey, and got our first year of data. I don't think I even did anything with it. But then, Tina went and did her own thing, and I ignored what I had been told, and I said, "I really want to keep developing this." Somehow Chris Marx got involved in it, because he was willing to do some of the online stuff, so he did the link with eBird, having related information set up through SurveyMonkey. And then Chris made an online thing for the dead birds. That was the big thing, because then I started getting interested in the dead birds, and I really wanted the live bird survey so I'd know what birds were seen, and then what were seen as dead. I was just trying to get proportions.

I've been wanting Steve to put dead birds into eBird. Let people report them dead or alive, please. I've talked to Pete Marra about this too, because he has this same interest in dead birds. I just had an interest in knowing… at first it was a cat focus, and then I tried to broaden it to be, whether it's window strikes, or whatever people could infer that it is. And I tried to get some measure of their inference. It's hard to have a protocol because it's just haphazard, and I've yet to see one that's good. You can't have people go out at some constant effort and look for dead birds, it's just going to always be this haphazard thing, and then what you can say about detectability? It just was a little shaky.

I was trying to look at which birds were most susceptible, at things like, what kind of natural history feature do they have? And, just like we would expect in backyards, it looks like maybe the ground foragers are more susceptible. Because they're on the ground, they just are more available. But then as Ken would say, "but none of them are endangered." Like, "so what? There's juncos everywhere [laughing], ok so juncos get killed by cats, but they're not…." And it's true, maybe demographically that has no impact, so that's always the other big question. But population impact is really hard to get at, and I don't think we'd get at that through citizen science. That's the only manuscript that I have drafted up. I get stuck a lot in analyses, on that one, because it's really hard to have a protocol.

I had also talked with Steve Kress, because I wanted to incorporate his work about gardening for birds Anyway, it just started building. And then I saw this way that we could use a polygon tool to actually collect habitat data, and that wasn't even in any of the plans for developing My Yard Counts.

My Yard Counts was small. I just had a few hundred participants, and I don't even know if I ran it for two years. I communicated a lot with the participants over email, because they knew it was a pilot, and I had asked for certain things. So it wasn't really hard to field their questions. They were all really smart, I mean, they had questions about my protocol. They didn't like the protocol, because there were these twenty-minute counts, and they knew that in those twenty minutes they were missing a lot of birds in their yard. They knew it was just a sample, and they hated that, because they had done FeederWatch where you can just record all day long. For the protocol, I had asked someone here who was visiting that year – a government person, who does a lot of surveys – I had asked, "what's the optimal time?" and he said, "15 minutes and you're going to saturate." That's what he kept saying. "Someone does a count for more than 15 minutes, there's just no point." So I think I said count 10 or 15 minutes at the same time of day, three days in a row, because I wanted it to be the first project where I could do occupancy analysis, so I could get some measure of detectability. I was trying to bring in a lot of these new, rigorous scientific protocols to the citizen science, because none of them had that yet.

Anyway, people would write and say, "I know I'm not seeing all my birds in 15 minutes, I have certain birds that tend to come in the morning, I have other birds that come in the evening, you're totally missing it." And so I said, "ok, for those who are interested, how about you do counts like for as much as you can? Go past 15 minutes, but keep track of how many you see every 5 minutes and we'll see…."

But it was interesting, because when I explained it, people ended up doing a whole bunch of twenty minute counts to see how the additional effort didn't result in that many more species. They could see how it would plateau, you know? And actually, it didn't plateau as quickly as I thought [laughs]! I mean, it would plateau really quickly, but then there was a secondary plateau. Which is what people were telling me, actually. They were saying, “well, but I get certain birds in the morning, and I get different birds in the evening.” Some people even graphed it for me, and you could actually see it would plateau, but then there’d be another plateau, and then another plateau. So I still felt like, “ok, I think stats can handle this, because we are measuring detectability, so we know we’re missing some.” But I didn’t really know how it would all play out, and then I was like, “ok, well, maybe we should sample in the evening and in the morning,” or you could have two sample times, maybe it’s just a temporal thing. I can’t ask people to watch all day. Anyway, it was interesting just to do that with participants. I mean it might have been only three or five people who actually sampled for longer periods. I think some went like two hours, and one guy went all day. There were some who were totally gung ho, it was just kind of fun.

But I never really felt like I dealt sufficiently with these little mini studies that they did, and with those results, because I didn’t know what to do with it. I was like, “oh my god, what do I do now?” You know? I mean, this is an unfunded project, I’m just doing it in my spare time, and… I don’t know, it’s so hard, data-management-wise, oh my god, if you did two counts a day, how am I going to distinguish these in my dataset? Because you’re just putting it in eBird with some comment lines. There wasn’t really the infrastructure to handle all this additional information, and I had no idea how to analyze it. Anyway, it was difficult. It was difficult.

And it was during that time that I got more interested in human dimensions, although I wasn’t yet calling it that. I was getting emails from people saying, “I’m seeing my yard as habitat, this is so awesome.” Oh, and I also got emails from people who were having conservation conflicts in their backyard. I remember this one person wrote and said, “a power company wants to clear this big band of habitat for power lines, right through my yard, and this is key bird area.” People get very concerned about their – but the whole premise of My Yard Counts was that every yard *does* count, because it’s part of this mosaic. You know, that just because it’s chopped up into little tiny parcels, we have to see it as one big picture, and every parcel needs to be important. And so people were hoping that I could help them, and they sent photographs, and asked, “what am I going to do?” They would try to use the project, and it’s affiliation with Cornell, to show that their property was important, and somehow should be exempt from this thing. And, you know, I mean, I didn’t really, I couldn’t help them. I had no idea what to do.

And I have to say that from participant feedback on My Yard Counts, one of the things that I wanted to have happen did happen, in that participants wrote back and said things like, “wow, I never, like I totally see my yard differently now, I see my yard as habitat.” And they hadn’t, they had that mental transformation which I was hoping they would have. They didn’t just see it as their yard. And so that was really good. You know, but obviously people were pre-selected, I mean they might have already had the propensity to view it that way. So, yeah, I thought it would be a really viable research venue.

Research and conservation. And I wrote about that, you know, when I wrote a paper about how we can harness citizen scientists to do conservation[14]. It was like pulling teeth to get that out, because I knew what I wanted to say, but it was really hard to write it somehow, and express it. But like I said, André never thought it was a good research venue, in terms of publishing in high-impact journals. And, I don't know, he might ultimately be proved right. So, so we'll see.

But, it was interesting just to see that there's tons of stuff that goes on in backyards. And most land is privately held. And, we're making more and more suburbs, and, it just seemed like a conservation issue in a way that people were really…. Like, I didn't know then about place attachment, and sense of place, and all that stuff that I've been reading now. But that's partly what interests me, is how people do have attachments to birds and to the place. Most bird watchers, I know now, actually do just watch around the house. It's really rare, the type we have around here, that go traveling around. So anyway, now I… I mean I guess the program was growing as I went, but I do see it as like, well, it was a social science. It's a social science platform to understand bird watchers, which is the way YardMap[15] has come to be.

I had meant My Yard Counts to be a pilot, that as a scientist I was seeing what would be the best protocols, and what could work. And developing the habitat stuff, at least in theory, and working on how that could be. So I was presenting all these things and it was turning into this project that was going to have these polygon tools where people could map their yards, and that was another way of providing habitat data. Because the hardest thing I've learned is that it was just insane to have people estimate the amount of trees they had, the amount of grass. The way we had it, people were just estimating. But it would be so cool to have it be that they could just draw it, and then we could extract from that whatever habitat index, or whatever, that we wanted. And this is how I was involved in the early, early stages of YardMaps.

So anyway, I had several hundred people in My Yard Counts, and with my data loggers I had like another forty over the course of a few years. And with those I dealt directly with participants. And then I've also met participants in person, because some of them have invited me to give talks to their Bluebird Societies and stuff, and so I've been to some of those Bluebird meetings. And that's always interesting. Most of those happened earlier on, and I wasn't prepared…. What's interesting there is that, each participant, they only see what they see, right? Their local study site. They don't have the big picture context. I put it all together, because I get what everybody sees, and I put it all together, and I see what trend there is. So I said, at one of those meetings, "hatching failure in this large-

[14] Cooper, C. B., J. Dickinson, T. B. Phillips, and R. Bonney. 2007. Citizen Science as a Tool for Conservation in Residential Ecosystems. Ecology and Society **12**:11.

[15] www.yardmap.org

scale picture is correlated with heat." And people hated that. Because from their own sites, at least in Virginia – this is where I was presenting – they said, "no, when it's rainy and wet, and cold, that is when we get hatching failure." And I said, "I know that's the picture you see, but on another level, it's another picture." And it's a really hard thing to put that together, and I… I never did a good job in conveying that, how there can be different scales, things happening at different levels. You know, or my stuff is wrong [laughs] – no, I'm just kidding. So, it's interesting, and it's actually challenging. It totally freaked me out, I thought, "I don't even know how to address that to them. I don't know how to…." I mean, it's not like something we're taught in school, how to do that kind of thing. I learned it a lot here, writing in BirdScope, about how to convey things to the public. But, it's hard.

Now the main research agenda that I've been trying to shape, the overarching goal of it is to understand nature based recreationists, mostly bird watchers – people who have birding as their hobby, before they necessarily enter citizen science – and how that is linked to conservation attitudes and behaviors. Whether it's through place attachment or whether it's through more science education or whether it's through just more attachment to nature. I'm still learning the literature on how that all works.

At some point it dawned on me that it's just an assumption that we work on at the Lab, thinking that, "oh, if people like birds, then people are into conservation." Maybe this came from watching birders, and seeing that disconnect, often? Or from just working at the Lab and being exposed to things like what Tina is doing, and informal science education, and, I don't know… I assume that's where I've been hearing it. And working on the NestWatch grant with Rick, and dealing with the participants … I don't know what made that transformation. But it just seems self-evident, that here are these people who are interested in conservation or are interested in birds… and that's what our goals are.

And then somehow, I don't even remember how, I got involved in the Marketing Department's surveys of Great Backyard Bird Count[16] participants. When I got interested in it and started talking to Mary Guthrie, and to Rick, I just suddenly realized, "oh my god, the Lab is totally missing this! This is the biggest vacant niche I've seen in a long time." This is just my opinion. I mean, I guess normally a marketing department would do it, study birders for marketing sake. But my thinking is, "we market conservation." I mean, yeah, we market products, and membership, but we're supposed to be marketing – if you will – conservation.

And then I started reading human dimensions literature and I realized, "this is a whole science! And we don't do it here!" It's the most obvious thing that we should study birdwatchers. Once it hit me, it's just totally obvious. And I knew Mary was behind me,

[16] http://gbbc.birdcount.org/

and Rick was behind me. And then André actually said, "you're right! If you can succeed in this then that is a great niche."

So my job description changed. We literally changed my job description so that it includes the human dimensions work. Now, I try to spend one week a month working on human dimensions. Because André didn't want for it to take over, either, so it's a little bit tricky. My job is still supposed to be the use of citizen science. André insists that. And I do like that little challenge of thinking, "ok, well what could citizen science do?" I had a recent grant proposal that just got rejected, but people said it was a good idea. They criticized the citizen science component, which… this is insane. The citizen science component, all it was, was sending video cameras to people, nest cams, these really cheap ones that we could get, so that they could record the laying time during the laying interval for their birds. All they have to do is set the time stamp correctly, there's no way to mess that up. And then we reduce the data, and we look at it, and we can estimate the window of time when the birds probably laid their eggs.

This whole proposal was basically about understanding the role of photoperiod on clutch size, because it's just worked out in circadian biology and you can study the time of day that the birds lay their eggs to test a lot of these hypotheses. We just wanted the natural patterns. Most of the proposal was to do stuff in the lab, with the collaborator, and to really work out the mechanisms of what's going on with the ovarian clock and this and that. But then we would also have a real-world component to see if we saw consistent patterns, and I said, "citizen science is perfect, that's what it does – patterns," right? You can get big, large-scale patterns, I could crowdsource people for videos they already take – because video cameras are so cheap, it's already popular for nest box people to be getting images. Plus I can recruit people at different sites, get tons of video, and see these large scale patterns of the time of day of laying, totally novel data that no one ever looks at other than the old timers like Skutch[17] and Margaret Morse[18].

On the broader impacts everybody said, "oh, this is so great, broader impacts." But then a couple of reviewers questioned, "are citizen scientists really capable?" I had already published a paper using volunteer data, from cams, for this very reason, and I thought I didn't have to dwell on all the abilities of citizen scientists. But apparently I still do. So when we revise it we're going to pitch that a little more strongly.

The lab species in this proposal happens to be starlings, because you can just get tons of them and nobody cares. Our field species were bluebirds and tree swallows, and people said, "no." Every reviewer said "no, have starlings as your field species." So I'm like, "fine, we'll have a couple of research sites with starlings, but to see the generalizability here of these patterns, we're going to keep that citizen science component." Plus it will keep the

[17] David Skutch
[18] Margaret Morse Nice

broader impacts. But it was a little upsetting to still encounter skepticism. Not all the reviewers had it. Some of them were like, "oh my god, what a great use of citizen scientists." A couple of them questioned it, but they probably weren't familiar with birders at all – some people wouldn't be. These were all more like molecular lab type people, so they might not be at all familiar with the type of people that would volunteer for this type of thing.

It was fun to find a project where literally the best route to get that large-scale data was through citizen scientists. But I have to say, when we revise the proposal, we will have real study sites. It became clear that we could have just a couple of study sites, for different latitudes, and if they're our own study sites we could get, like, real data. Because it would be with starlings – which citizen scientists hate anyway – but we could sacrifice the birds, get blood samples, and do real time PCR, and ovarian gene clock, all these invasive things that you could never do with citizen science. And I'm sure the proposal would be stronger. I mean, pretty much that's what people say, "why don't you have a real study site?" But I'm going to still keep the citizen science part in it. And we probably won't use the word citizen science[19]. I think we'll probably just start calling them bird recreationists, nest box enthusiasts, or whatever.

So why do I keep dreaming up new projects? Well, there's only so much you can dredge out of the existing data [laughing]! I mean, I am working on a paper right now using the NestWatch data, that's also related to this proposal. And I'm sure there's climate change things to do. It's just hard using the existing data, because some of the best ways to use it would be with other data sources. I've talked to Daniel Fink about using the NDVI with NestWatch … it's basically the greening up data, from satellites. He's using it all the time with Ben, with bird distribution data. And I'm thinking, "that's interesting, but ***this*** would really be interesting: nesting, timing, phenology." But I don't really want to take it on, on my own. I can hear them talking about it, it sounds like it's a bear to work with. And then there's the climate data. These are detailed weather data for the past, and I think they have future projections too. Ben's worked with it for the Northeast, but they don't have the South finished. I've just been waiting for it, because they keep saying they're going to have it. If I do a paper, it's latitudinally important to have data from across the north and south – the wide range of latitudes rather than just one region – so I'm waiting. But with the data by itself, I guess I could probably brainstorm more, but… I don't know, I haven't seen as much there of interest.

[19] Changing terminology is not unprecedented, and may in fact be strategic. In personal conversation with Terry Root at the 2012 PPSR Conference in Portland, Terry mentioned that she would use the terminology "non-traditional data" to offset concerns by reviewers. This may complicate the scientific credibility of the overall research approach, however, as it is difficult to track and compile a body of evidence pointing to the usefulness and relevance of volunteer-collected data when the use of those data is obscured.

I guess I'm not the only one that thinks that way, because Wes told me the other day that Bart Kempenaers – he's at the Max Plank Institute, he was one of André's students, and he's a shooting star ornithologist – he wants to start a NestWatch kind of project across Europe. So, Wes is going to write a proposal for a planning workshop, and he asked me to be a co-PI, which was good, and I said "of course." That's my niche, right? But what's cool is that Bart's vision for it isn't about just getting all the basic monitoring data – which I hope he will still want to get – but he basically wants to use it as a network, to send out for side projects, like the way Janis did with the personality profile. When she first got here she did this side project to see about fear in birds, neophobia, the fear of novel things. She had NestWatch participants put little bows and things on nest boxes, to see how the birds responded. That's an example of thinking, "ok, you have this network of people, what can you ask them to do for an experiment?" That's what Bart wants to do, he wants to establish that network for side projects. I think he has a lot of ideas on what he wants them to do.

I think that's one of the really good things about citizen science. We write about that some, about this army of people who are ready for something. Like if some new insights come from the dead birds falling from the sky[20], like what happened with the house finch disease – there's this group of people who are right there and ready, and they can start a new protocol and get data like that [snaps]. And, I guess it's hard to dredge the current data, but it's fun to brainstorm more uses.

I also decided that – for years here I had tried to do conservation work, because when I came here, my PhD was conservation biology oriented. I came here wanting to do that, and all I was doing was this life history stuff – basic ecology, not applied at all. And every year or so I'd ask, "what can I do, what could I do that would help conservation?" But I never got like a clear sense of what that was, so… I kind of gave up. And now I decided that my conservation work is human dimensions. It's not ecology at all, even though I think that's great. But it's not what I can do here. I can't do the dead birds, I can't do residential landscapes – that was somewhat conservation oriented. So I will do… human dimensions work. And that will be my conservation stuff.

Ultimately, for so many conservation topics on the ecology end of things, we know what we need to know. We know what we need to know to conserve birds, we know what habitat we need to protect. We know what practices we need to do and what things we don't need to do. We know what the major threats are. But yet, we get that gap, in that we can't… it's all about implementing it. The human dimensions come into that. It was actually something Ashley Dayer had said about it to me, saying, "even when we manage birds, we're really managing people." We're not telling birds to migrate sooner, or to breed earlier or later. We can't really control what they do per se. We manage people,

[20] A phenomenon that made national news several times in succession during 2010.

and so we have to understand their motives and their behaviors, broadening that system and understanding the complexity there.

And then when I was talking with Dan Decker over in the Human Dimensions Research Unit he said, "for the last 20 years all the advances made in deer management have been from understanding hunters," because we have long known what we have to do to manage a deer population, for example. So I was just thinking that it's somewhat the same with birds, that probably the biggest advances in bird conservation – I mean, the science is definitely important and there's things to work on there, but I didn't feel I would be doing them here, or leveraging citizen science necessarily to do it. But it seemed like there was this open area in human dimensions research, and especially one that citizen science could play a role in – or citizen scientists. That just seemed like a big gap.

So now I'm pursuing this question about nature-based recreationists and citizen scientists, and what their relationship is to conservation. That's a natural outgrowth, I think. I think it stems from the early stuff with My Yard Counts, all the precursor stuff to YardMap, and that paper that I did with people here focused on conservation in residential landscapes. It was this whole idea that most people live in these suburban settings, and maybe most land is private, not publically owned. A lot of it is therefore not accessible for managing, and a lot of it is really fragmented. We always think of remote places as really hard to access for ecology, when actually a private land holding is really hard to access. But that's where citizen scientists collect their data. So thinking of it from that perspective: first, we can get our ecology data from people. But then to actually use it in any kind of management way would involve people, so you have to understand them as well. With a lot of people owning a little bit of land, they would have to coordinate to manage according to a common goal. I mean, they're just part of the system. Kind of that coupled system idea – ecology, and people being part of it. So, it stemmed from wanting to just understand the ecology side, and leveraging citizen scientists to understand the ecology, and then realizing, well, anything we would do would need to involve them, too. So, understanding people.

What came out of that paper on residential landscapes was the first typology, that there are different types of projects[21]. Here, we're very top-down. Anything we do would be coordinated in a very top-down way, coordinating a lot of stakeholders or a lot of participants in a top-down way, it would be us setting the effort. "Oh, we want brush-piles in backyards," ok, we're going to coordinate brush-piles, you know, whatever it is. Whereas there are other projects that happen in citizen science that are more bottom-up, which I can totally see. I mean, the benefit with citizen science isn't just that people

[21] Cooper, C. B., J. Dickinson, T. B. Phillips, and R. Bonney. 2007. Citizen science as a tool for conservation in residential ecosystems. *Ecology and Society* 12(2):11. [online] URL: http://www.ecologyandsociety.org/vol12/iss2/art11/

collect the data but that they're vested in it, in figuring out – I mean, ideally they're vested in whatever the common vision is. Or you could call it the common problem, you know, that they all see a problem that they want to solve, or they see a vision, a place where they want to get to. And citizen science is just that tool for coordinating the data, coordinating the information, and getting people to act in a coordinated way. It's that cumulative impact, but a positive one, instead of what usually happens, which is this uncoordinated thing that makes bad, negative cumulative impacts.

Before graduate school I worked with wetland permit reviews, and my job was to figure out how to assess cumulative impacts. Most permit reviews are set up so you just review them when they come in, and you review it and assess on that one that thing, so there's no structure there to do cumulative impacts. This was all for lakes, and it would be like, this person wants to put up a wall to protect against erosion. Well, it's the first one on the lake, so that's fine. Then *this* person wants to do it… well, that's ok. But then when the tenth person wants to do it, suddenly you're looking at a cumulative impact, but you've set a precedent and so you can't do anything. But I found one area in Oregon where they actually made a whole plan ahead of time of what all the acceptable impacts can be, and then every permit was reviewed in that plan, no or yes. It either fits with it or it doesn't, because it was a predictive thing about the cumulative impact. The point was, it had to be coordinated, and it can't be this haphazard thing. It was a big lesson, this whole thing about cumulative impacts, because each little thing doesn't seem like much, but when you put it all together, you get this big effect. And that's so how it is with residential systems, I think. But then turn that around – so instead of everybody doing their own thing, they're coordinating and making a positive impact. I mean, because obviously you could do it in a good way too then, right? If every single person doing something little ends up making this big mess, certainly it could be the other way and make it be good, culminating with a positive influence.

And now I'm looking at the overlap between citizen science and urban planning. I didn't really know anything about urban planning, I'd always been curious about it, but this Fellow, Carlos Nuñes Silva, who's editing a book on urban planning saw that article on residential landscapes and contacted me to do a book chapter in his new book. So I started looking into it, and realized that there is this huge literature in urban planning, on e-participation in urban planning and in local governance. They'd been using all these web tools, mostly it's e-mapping. For these planners to make these plans, they have to get information, they need to know things like what bike routes people are taking. A big one that was in the news a lot was the one about, "where are all the public restrooms in NYC?" So they make these Google mash-ups, they build these platforms, for iPhone users or whoever, to just add their data. But compared to citizen science, it doesn't have this big education wrapper around it like we would necessarily have. And since it's often planning and governance, it really should have less of a bias. In terms of… they're reaching iPhone users, you know? Hopefully it would be a little more democratic. Like, we try to reach other audiences, but it's just because we want science education everywhere. But in their case it's, you know, we're talking about a participatory form of governance, so you really want broader participation.

There are so many corollaries to what is going on there with citizen participation in governance and citizen participation in science, like what we do. So when I was looking at it I started thinking, "oh my god, there's going to be total cross-fertilization," which is what Carlos saw as well. And so I'm partnered with Ashwin Balakrishnan, a community organizer in the City, to write a chapter together. We had to put in a proposal and it got accepted[22]. So I'm excited about that. I talked to Rhiannon [Crain] about it too, because she's tapped into that, with YardMap. When I had thought of YardMap, and the way it turned out, too, it doesn't have any governance at the top. It's actually just putting it out there, for people to put their information together, and social network, and inform each other. And maybe something might emerge, or maybe the Lab would say, "oh let's try this", but there's no set agenda. It would be even cooler I guess if an actual governing body were using YardMap to coordinate participants in a planning project, I think. That's what the urban planners always use, they use these mapping tools. But it could be even better. So, I haven't delved into their stuff too much yet. But we're going to write best practices in citizen science and touch on all these different topics, like about broadening participation and all the side benefits of engaging participants and all that. What I've seen in the literature is that they've mostly taken this "build it and they will come" approach, and it's failed miserably. Our chapter is for urban planners, so it's just providing what we know about citizen science, but I'm actually most interested in learning more about what they do and bringing it back to our field.

And then there's my book idea, the thesis that I'm developing in that … well, there's multiple threads in it. But one does relate to kind of this science/society conflict that often happens, I mean public perceptions about science, and even scientists' perceptions about science, and the way it's always portrayed as this very serious method, you know – it's all the brain, it's all this way of thinking. And that's all accurate, it *is* this method, it *is* these different things, a body of knowledge and this process. But at the same time I think when we look at it from a citizen scientist's perspective and public participation in science, it's still science, but it's like this whole new beast, right? I mean it totally flips it upside down and it's not just this thing, this brainiac thing. There are these other dimensions to it that are – I guess they're at the emotional level instead of just the rational level, but I don't mean that in a bad way. I'm just saying, I think everyone – I think there's so many other reasons for people to participate in citizen science that aren't really looked at, because of the way we ask the questions. And what it does for people and for society. I mean, eventually what I'm getting at is I do think it's linked to democracy. Just like you have to have an even distribution of wealth, you have to have an

[22] Cooper, C. B. and A. Balakrishnan. 2013. Citizen Science perspectives on e-participation in urban planning. Contributed chapter to Citizen e-participation in Urban Governance. IGI Press.

even distribution of knowledge, and access to knowledge, and processes that make things happen, like science. But even just to get there, it's also this acknowledgment that any decision-making involves so much more than just data, it involves – it's like our whole body, right? It's our whole being and how we make decisions about things or move forward as a society. And so science always is like, "well, this is just our role, and we add this bit of information," but I think it actually is more than that, because through doing science – or these processes – it's how we get engaged in things, it's how we start figuring out what our values are.

I wish I could remember what my attitudes were about science when I started. I definitely have different attitudes – I think I used to think science was the most important thing. Like if people just understood it, if people just took the data, as though the data somehow tells you all you need to know. Which is just so not true. You know, it just tells you a number… like with fracking. Oh, it tells you the risk, yeah. Maybe my well has a 10% chance of being contaminated. But that's not a decision. That all depends on my values vs. somebody else's values, right? "For me, 10% is too high." Somebody else might say, "well, 10% is just fine." It obviously has to be in this bigger context, and I think I never quite understood how that was.

My own research still is so basic, in terms what I use citizen science for. But I do have two proposals that I'm going to resubmit – they were rejected again – and they both had citizen science components. One of them got mixed reviews about the citizen science component, and the other one, actually, it was the first time every reviewer loved the citizen science part. It involves having participants take photographs of house sparrow eggs before they destroy them, because most of them will destroy them. We would have them take standardized photos and send them to us – if I could do it I'd have them send the eggs, but I don't think it would work. This was written up in BirdScope, and I got an angry letter from a guy saying, "I hope this isn't tax-payer funded, because this is so ridiculous, you're studying the color of house sparrow eggs when they're out there destroying our bluebird nests. Why aren't you studying how to control house sparrows?" It was a really good question, because from his perspective, he's out there in the field, and he wants bluebirds, he doesn't want this exotic species, and then he sees this research project that's not even addressing this pragmatic problem.

I wrote him back about basic research and applied research and how they're both really important, and that the answers to his question might be really site-specific and really hard for me to tell. Which is kind of lame. I mean, it was a somewhat true answer, but also I hadn't really looked at the literature to see if there is a common thread. I know people have looked at it, and that there's probably a lot of information that's not even published, that people have tried stuff, and it's just not all together. And I don't think we've ever leveraged our citizen science community well enough to study how to control house sparrows. It probably is a question we could answer. And so, hmm, I guess that means I'm not using a collaborative or co-created model of citizen science, because if that really is what's of interest to people who are interested in birds, then I should be doing that. I mean, is that what I should be doing? I don't know. If we get funding and I carry it out, I know I would approach it differently than I would have before.

My research vein has been so basic in terms of understanding stuff about basic biology, that it hasn't…. I know from experiences that I've read about that basic science has more often been the most informative thing toward management than these really site-specific studies, but you often don't know what it's going to reveal ahead of time. So if we do get funding for the house sparrow project, I guess I'd have to think a lot about how to maybe dovetail it to be more multi-purpose, in terms of information I get form participants other than just egg photos. Like information about what they might have done to try to prevent the house sparrows, what management they did after, what effects…. Just to make it more relevant, so that it's serving them more directly, given that they'd be giving me data to serve this other goal. I don't know. I feel a little bad, because I guess I feel almost like I haven't – that all of this hasn't revised how I do at least that part of my research. It's definitely affected my whole interest in human dimensions, but in terms of my ecology research, it hasn't really. Not that I think it's like a little democracy and all the citizen scientists should vote and say what my research priorities should be, but it's definitely a voice to listen to, to assess what science is for and who it's serving, and then how to set priorities.

But you know how research with citizen science data is done – it's so haphazard. It's so opportunistic, right? I mean, the path that led me down this road of looking at photoperiod really just came with the territory of looking at NestWatch data and this question of large-scale patterns in clutch size. That led me to look at photoperiod, and then all the influences of photoperiod. I think it might be that way with a lot of science, for everybody. It gets really opportunistic. Even if you look at the Lab, and all the different research programs, it's not like anybody said, "oh, let's set this up so we study this bird, and this whale, and this elephant," you know what I mean? It was all these opportunities, and people went out there. So that doesn't mean it was necessarily this thought out thing, strategically, like this is the most highly relevant societal thing to do.

There is a way that my view of science has changed. When I graduated and got my dissertation, to me science meant one thing. This is so lame – it meant publishing. And I firmly believed that it's as though nothing happens if it doesn't end up published where other people can read about it. There are so many people who would do their research, and learn a lot, and maybe find an answer, but then they just never took it to the next level and shared it with everybody else. So to me, I thought, if you can't take it to that final level, it's as though it doesn't exist. Which is kind of funny, kind of like birding. If you see the bird, that's fine, but if you don't put it in eBird, where everyone can see that observation, then what good is it? Right? It was kind of that attitude.

And I still think that it's totally important, I'm not saying it's not. But I can see that there is so much more that can happen from the whole scientific process, especially in the citizen science context, beyond that one outcome. There are multiple, multiple, multiple outcomes. And so I guess I'm also saying that there are multiple things of what science is. So when I think about urban planning, and they think about their data gathering, I don't even think they would call it science, but to me that's the same thing. It's just that they're not using it to make a publication, but it's still science, and the people that participate in it and give observations and are making decisions, or help making decisions, that's totally science. I think a lot of people wish science was more of that process, more inclusive, using information for making decisions. It seems like science itself has become so separated, it's now hard to push it back in and even get a clear picture of how it fits. But in these places like urban planning where it's the same process – observing, gathering information, and so on – it's all integrated and it's not called science, but it actually happens. And I guess I do want it to be more fluid. I think citizen science moves science to being more fluid and integrated with – I hate using the word "decision-making" in such a generic way, but that's what it is. We make decisions and things happen.

And I think people like to leave a legacy. I mean, why would somebody who goes birding take that extra step to put their data in the database, unless you want to be contributing, you know? I feel like people like to leave their mark in some way. Even just the term "participating," means you're being part of something bigger than your own little sphere, and bigger than yourself. So I think citizen science can help redefine how science looks to people. Like, instead of science being this other thing that's so divorced from all realms of life, you know what I mean? That's just, "I don't feel like thinking," or that "it just belongs in this one little place." I think citizen science participation really helps integrate science into everyday life. Because I think it is. I mean, from the moment we're born, people are observing, right? We're using all of our senses to just make sense of the world, and that's all that science is. Except it always just pretends that it has no bias and no other objectives, and… you know what I mean? But it's there for a purpose, it's to serve society. So I think people working in the service of science to ensure that science definitely is working for them – that's just a connection that citizen science can make. I know I'm being really vague, but I guess that I see it bridging that society/science gap, really redefining the role that people see science as playing, and that scientists see it a little differently too.

Matthew Godfrey

North Carolina Wildlife Resources Commission

Working within a larger system

At the close of one of my formal interview conversations with Matthew, conversations that took place over the course of several years, he expressed interest in reviewing his interview transcripts. Matthew voiced a suspicion that his own thinking about work with volunteers with may have changed, perhaps even "radically." He had moved from working as a researcher to take on the responsibility of managing of turtle populations in North Carolina, which involved managing an existing volunteer monitoring network. He shares his interest in helping volunteers to see the larger ecological system of turtles, beyond their time on the single beach where volunteers encounter them. Matthew's story also invites reflection on his own role working within a larger, human system for turtle management.

My official position is state sea turtle biologist with North Carolina. I work with the Wildlife Resources Commission, which is a state agency. Essentially, they're responsible for game and non-game wildlife – historically more heavy on the game than non-game, although the non-game side, that is the protected species side, is growing and has been growing for the past twenty years. It's gone from just a couple people to maybe about 25 now. The sea turtle program was one of the first non-game programs established in North Carolina at the state level, so it's got a long history. What happened was, when it was first set up back in the '80s, the one biologist that was working on it realized there was no way that he could collect data relevant to sea turtle management himself. So he thought it would be a really good opportunity to ask if there were any public citizens that were interested in helping out, volunteering as a way to get information and also to get them involved in non-game wildlife protected species management. That's actually one of the objectives of our agency, to increase public participation across the board, both in game management – including hunting and fishing – and protecting or watching non-game wildlife. So I think that was the impetus originally, and over time it grew from just a few beaches in the state, maybe a dozen or so miles of beach – to pretty much the entire state now, and we have about 330 miles of ocean-side beach coastline.

It really grew in the mid-'90s when they actually hired someone to be the official state sea turtle person and that was the only job that that person did. The woman at that time, her name was Ruth, really tried hard to bring in as many people as possible and pretty much had a volunteer-based management for sea turtles in the state. Of course, it's not only volunteers – we have state agencies like State Parks that have a few beaches where they have paid personnel, state rangers, that do the monitoring. And then there are the National Seashores, which have federal employees – rangers – that do the work there.

We even have a beach within camp Lejeune, which is a Marine Corps base, where they have paid bio-technicians that do the work there. But I'd say about half the state is covered by volunteers, private citizen volunteers.

So when I came to work here in 2002 I pretty much walked into this system that had already been set up, and my job was just to keep it going, to basically manage and protect sea turtles as they come to nest. They come here both for foraging – they're in the water for foraging – and then they come to nest in the summer. Half my job is managing the protection activities associated with sea turtle nests – nesting females and their eggs, and their hatchlings that come out later – and then the other half is dealing with any dead or injured turtles that might show up on our beaches, that's the stranding network. We use volunteers for both those aspects, and the same people that do the nest protection end up doing a lot of work with the stranding network also. They're out there usually every day looking at nests, so if they see a dead or injured turtle they respond to that too. So, my job basically is managing a large network of over 750 people – volunteers and cooperators – trying to maintain minimum standardized methods of data collection and management, and things like that. Make sure they have what basic equipment they need, that they're getting their data to me, responding to their needs, just so we can have effective management of sea turtles in the state.

The program was set up when I walked into it, so I can't imagine how challenging it must have been to set up originally. But it's like it's got a life of it's own – a lot of the volunteers are really well organized themselves. They have their sub-groups and some of them are even incorporated into non-profit organizations, small non-profit groups that do other work, too. So everybody's totally committed to it, which is great. It's not really contentious, we're all on the same side working towards the same thing, so it's quite a nice supportive environment to be working in.

I've worked on other sea turtle projects in the past that have used both paid and volunteer people that have been involved, and I've also served as a volunteer in a number of projects, but never to this extent ever. It's usually just been a handful of people here and there occasionally, and nothing as organized as this one is. Once, as a favor for a friend – it was very difficult, a real sacrifice – I went to the Virgin Islands for two months to help out on a leatherback project there. There were two local high school students that were volunteering, so in addition to the regular monitoring that I was doing I told him that I would help get them involved to provide an opportunity for them to experience what we were doing on the beach, and to take part in the process of collecting data and trying to manage the nests and things like that. That's the kind of level that I was used to, just a handful of people here and there, one on one, maybe two on one, and then that's it. Very, very low key.

The very first turtle project I worked on was a separate time, but it was also the Virgin Islands. It was on a different beach, on the island with Hawksbill turtles. I was actually a paid seasonal ranger with the park service. There were three of us that were paid and there were another four people that were volunteers, and we all worked together to do net patrols on the beach. That was my first experience working with volunteers.

I've never thought about it in terms of paid vs. non-paid – I guess my initial thought is that, it just seemed like we were all considered equals. The only difference was that some of us could drive the boat and some of us could not, to get out to the island. But pretty much all the work that we did was equal. I also think all of us at that time, none of us had prior training for that particular kind of work, so we were all starting from the same spot. That might have played into it. But it was very positive – we all worked together, we all got along. I can't remember any conflicts over who was being paid and who wasn't being paid, and any data quality issues or anything like that. I think everything was fine on that end.

I worked on a bunch of different projects in different places, usually in different countries, but always as an outsider coming as a short-term worker or guest-researcher. It was great for me, a great experience. I always participated as much as I could in the project, but I always definitely felt like an outsider, and I never really had an active role in making a lot of the day-to-day management decisions. So I thought the best thing for me to do would be to try to get a job somewhere that would allow me to make day-to-day management decisions, because – in my very naïve worldview at that time – clearly I am the best and I know the proper way of doing things and if only I had a job where I could show everybody I knew how to do things in the right way, everything would just be perfect. I was basically looking for some kind of position like this where I was running a management project for sea turtles. So when this came up – I knew the woman that used to work in this position, and when she moved on she asked me if I'd be interested, and I said "yes, absolutely." That sort of helped me get the position. But I was very starry-eyed when I first started here. I really had no idea what the job was going to entail, what it means to work with volunteers at this kind of scale, anything like that. I had no idea.

Probably the strongest thoughts I had were that it was going to be very difficult to get a lot of the volunteers to accept me in my position because, first, most of them are a few decades older than I am, so there's the age difference. And Ruth, who set up the majority of the volunteer network here – people were already not very keen about anybody who was going to be replacing Ruth. So, I felt like I had an uphill battle to go to get people to accept me. And I was very unsure about how to interact with people because it's a little bit strange working with volunteers, because they are volunteers. They're not paid, so you know you can only push them so hard, you can only have so many expectations of them. And yet, you do have certain expectations of them. They, on the other hand, have certain expectations, and they realize that they're not paid and so they will only be allowed to be pushed so far. So for me initially, I was just sort of feeling my way as to how I should establish my relationship – whether I could establish my relationship with them. And how it was all going to turn out.

A lot of it was just reacting to their input, their needs, their queries, things like that. I did not initially reach out to them very strongly, I was much more passive about it, and let them come to me. The way we have it set up is that we have 22 different beach units in the state, and each beach unit has a beach coordinator and that's the person usually that I talked to. And then each beach coordinator is responsible for their cooperators or volunteers. So for instance, there's a beach nearby here called Emerald Isle, and there are two coordinators there, and they're responsible for the 65-70 volunteers. I talk fairly regularly with the 2 coordinators, and not so regularly with the volunteers on the ground. So initially I was just waiting for the volunteer coordinators to contact me with whatever they needed, or their questions, or anything like that. And we have yearly meetings. We meet up with them to make sure that they have everything that they need, and any kind of training that they require, we'll do things like that, buy supplies, etc. But apart from that, initially I was very passive and just waiting for them to contact me, to let them establish the relationship of how close or not close they wanted to be. And to express as strongly or not as strongly the things that they needed.

Over time you get to know people better, and you understand – because you get all sorts of personalities, some quite strong – that some are more able to voice their needs and their desires quite clearly and quite loudly. And others that might not do that, but still they do have needs that need to be met. It took a long time for me to parse all that out and figure out the different personalities, and define my relationship with them and try and figure out exactly what's the best way to meet their needs to maximize their work within the sea turtle project.

The number one thing that I do is I carry a cell phone with me all the time, 24 hours a day, 7 days a week. That's our hotline that they're supposed to call if there's a dead or injured turtle, or some kind of emergency. Some people call just if they've got a question or something like that. I try to respond immediately to all queries about everything. And I think that's really helped over time – I think they feel reassured that there's somebody there that they can call if they do have an issue. Sometimes it's a little bit silly, they call because they don't have any pens or something, but I do think that's really important that they do get a response, that they do know that there's someone there, available to try to meet their needs. I think that's the number one thing that I try to do.

In terms of the data collection, there's not much wiggle room because the sea turtles are a protected species. It's a federally mandated protection system. Because they're on the endangered species act, by law there has to be a recovery plan in place and the recovery plan is quite a big document that lays out what you can and cannot do, to basically try to keep them from being killed, and try to protect them as much as possible. Our agency has agreements with the Fish and Wildlife Service and the National Fisheries Service, those are the two federal agencies that are responsible for managing the protection of sea turtles in the US. We have cooperative agreements with them that let us act on their behalf, and then we in turn give permits out to our volunteers to follow those rules and regulations. Everything is standardized about what you can and cannot do. We have a handbook in the state that has guidelines that volunteers are supposed to follow at all times, and we try to have in there every conceivable situation they might encounter. Of course, there are always some that we have not considered, but they know that they can call at any time and ask, and usually I'll deal with it on a case-by-case basis. So there are minimum standards for collecting information about things like the nests – every nest we want to know where, when, what species, you know, how successful it was, how many hatchlings came out, things like that. Those are the minimum data that they're supposed to acquire, and they know what they're supposed to do.

In the past the data has all been on paper, but recently we've moved to an online reporting system, which has been really good actually because it has allowed me to learn even more in real time where some of the issues are, where some of the confusion is on the volunteers' side. We have minimum data requirements that we ask them to collect, and in recent years it's become much more standardized because of the online reporting system. They go online daily and they upload everything. And we set it up so if they miss something, a window pops up and says, "you haven't filled that in," or, "these data are missing," or "that's an incorrect date." They've been great on that. By and large they're really good about keeping track of their data, and data management, they're pretty keen about it. I issue yearly permits to them that specify that they're responsible for keeping track of data and submitting it in a timely fashion, and occasionally I've had to remind beach coordinators that it says on the permit that if they want to continue as beach coordinator they need to live up to the agreement of the permit. But it's usually not an issue, or anything like that. It's just a friendly reminder to them.

I try to go through everything and do a quick QA/QC on the data, because sometimes there are typos and transcription errors and things like that. Or there are things that I just don't understand that they've written down, so I try to get in touch with them as soon as possible, while things are still fresh in their mind. That's why our new online system is a lot better because I can see it in real time – and they're pretty good about entering it in real time – so I can see right away if there are issues, and contact them immediately. And it's much better for ensuring that the data are clear and there are no errors – or there's minimal number of errors and things like that. I do try to look over everything make sure that there are no really obvious errors. There are always going to be some errors, I mean everybody makes them, I make them, that's just a fact of life. I'm guessing it's probably about 10% of the records have errors but that's just the way it is. And I'm sure it's balanced out in both directions so it comes out about average. And it probably doesn't affect the results at all. So you know, if they're overestimating something half the time and they're underestimating something half the time, then overall the average is still going to be the same. There's no reason for me to think that they're always overestimating or underestimating particular things, it's usually just transcription errors, that they switched numbers or something. I haven't done any QA/QC on error rates but folks in Florida have, and they say it's somewhere between 8 and 10% on some things, not everything. On the few things that they've looked at they say it's between 8 and 10% but that seems about right to me, between 8 and 10%. But hey, if I only make errors on 8-10% of the things that I do, I'd feel pretty good myself.

A lot of them are just typographical mistakes. There's a long data field and a lot of times people forget to put negative, and so we've got a little map that shows where the nest is and I'd say about 20% of the time the nests appear to be in Kyrgyzstan and Asia, but it's just because of typos like that. But those kinds of things show up, and when they do show up it's so much easier to get people to look at it within a week or so, or a couple days, and say "hey what did you mean by that?" And they can say, "oh yeah, I meant this," and they correct it right away. As opposed to waiting until the end of the year in December when I get hard copies, and I start looking through them, and I find something and I call them and I say "hey, what about this nest in May, last May?" and they're like "I can't remember where that nest was." So, it's much better for correcting even little things closer to when the data were collected and entered, so we can remind people when their memories are fresh. But it's mostly typographical stuff. Sometimes, they'll be a bit confused about what data go where, and so if it shows up, if it looks weird I'll just call them right away or email them and usually they respond immediately and say, "oh yeah, I wasn't sure about that, I put it there but I'm not sure," and I can just tell them, "no, actually it should go here," and that's the way it is. And usually they say, "ok, now I know, and I'll just do it that way from now on," and 99.9% of the time it's that way.

All the data that we gather I compile into a centralized database, and then I share those data with the two federal agencies. And actually, pretty much anyone else that wants them can have them, but it's by and large the two federal agencies that are interested. And they use them all the time for management purposes, for reviewing biological opinions, for setting up new management schemes, for reviewing incidental take permits, etc. etc. It's funny, just today I had an email from someone down at the NOAA regional office who wanted data on nest numbers from 2010 as part of a biological opinion for a certain fishery in the Gulf of Mexico. I try to reiterate this to all our volunteers that the work they do is feeding into this larger system where the data are used to make management decisions at the national level, that do affect the sea turtles.

Officially, the turtles that nest in Georgia, North Carolina, and South Carolina are considered part of a regional management unit called the Northern sub-population of loggerheads. So there is a biological underpinning for why we'd want to talk to each other. But the other thing is that it turns out that we happen to be buddies from the past, so we all know each other from previous situations, so we end up actually talking to each other probably once a week if not more sometimes, about things. And plus we've tried some of the online data management stuff that I've been telling you, all three of us are trying to do it at the same time, not only to improve the time and quality of the data, but also to standardize across the three states because we felt it would be pretty important, if we're all part of the same regional management unit, that we should all be collecting the data in the same way. So we've been working really hard to try to standardize the way we do things. On some of the issues like nest relocation, things like that, we by and large agree. I'd say generally there are some things that we disagree on, which is fine, I mean it's really hard to have things completely standardized, especially since beaches are so variable, and situations are so variable, over the different geographic range that we're talking about. But yeah, we do talk quite a bit. They, South Carolina, also use volunteers quite a bit. Georgia uses some volunteers, not as many as North Carolina or South Carolina. But they also use volunteers. So we face a lot of the similar issues that come up and we end up sharing a lot of our experiences and asking each other advice on a lot of things.

So the three states got together and worked with the webmaster on seaturtle.org to set up this online reporting system – the idea being that not only would it make it easier for the three states' turtle coordinators, because we wouldn't have to enter the data anymore when we get the hard copies, we'd let the volunteers do it. But also it would standardize across the three states, and make sure that we're all doing things the same way. And that's been great, it's the third year now that it's up and running. And not only does it make it much easier, and also reduces a number of errors and things like that, but the volunteers get real-time access, they can see what's going on, not only on their beach but on other beaches right away. They can see what's happening in other states. And it's also exposed some of the things that we hadn't thought about in the past, some of the potential problems with the way data are collected or reported that we've had to tweak to fix, which has been great. So it's just been this ongoing process of improving the way that we collect data. And also it's much easier now to compare our North Carolina data with South Carolina data with Georgia data, because we all do it the same way and we're all using the same fields, and we all have the same definitions of things. So it's been great.

In the US, turtles are listed as threatened or endangered, so they fall under either NOAA or Fish and Wildlife Service purview, and they need to do annual reports on status of turtles. And quite often they'll use numbers of nests laid per management unit. Right now, the northern management unit for loggerheads is considered to be Georgia, South Carolina, and North Carolina together. So it's really easy for them when they want to know "hey, what was the nesting activity last year?" We can just say, "go online and look." And they can go to the summary page and get those data straightaway. They use those for writing up annual reports or doing 5-year reviews for the endangered species act, things like that[1]. So that's been really helpful, both for them and for us, and NOAA has been the same way when they have to do various status reviews, they pull the data off the website also.

For instance, because all the sea turtles are listed as threatened or endangered, they have to have these recovery plans written which establish not only what activities you can and cannot do to try to recover them, but what recovery criteria are. The most recent version of the recovery plans for loggerheads came out at the end of 2009[2] and the recovery criteria were based upon previous nest numbers laid in North Carolina, South Carolina, and Georgia. I've tried to point that out to the volunteers, that not only are the nest data that the volunteers collect – not only were they important for setting those criteria, but they're actually really important for evaluating the criteria in the future, because it's all about reaching minimum thresholds of numbers of nests laid per year. So their ongoing efforts are leading towards the evaluation of these criteria. And there's other things, there's stranding information and other things like that, that are part of the recovery plan that the volunteers' activities are really important, and lead directly into. Related to that, there was a master's student who did a general mail survey of volunteers, asking basic questions. One of the questions was something like, "what do you feel could be improved the most" or something like that. It came back that most of the volunteers did not understand how the data collected were being used for management. So that's led to me trying to tell them again and again why it's so important. Hopefully that message is getting across.

I found that when I ask all the beach coordinators to come and I talk to them – we get about 60 or 70 people coming, and they're supposed to go back and talk to their groups and explain things to them, but I'm not sure how much that actually trickles down. So I've been trying to go to the individual groups at least once every year or so to have meetings with everybody who's available, to try to tell them these things. I used to think that if I just said something once or twice, that was good enough, they would remember it – but I think there's just a lot of information that I assumed was getting processed but actually was not getting processed. So I tried to change my approach and just say the same things over and over again, every time I see them. So I feel like I've been telling them this for 3 or 4 years now, but I will continue to tell them well into the future. And you know, every time they do seem happy to hear that and impressed, and they like it. Nobody's ever told me "yeah, yeah, we know that, shut up, tell us something new."

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[1] A long list of peer-reviewed publications and reports using NOAA sea turtle data is available online: http://www.sefsc.noaa.gov/species/turtles/peerreviewed.htm

[2] Conant, T. A., Dutton, P. H., Eguchi, T., Epperly, S. P., Fahy, C. C., Godfrey, M. H., ... & Witherington, B. E. (2009). Loggerhead sea turtle (Caretta caretta) 2009 status review under the US Endangered Species Act. *Report of the loggerhead biological review Team to the National Marine Fisheries Service*, *222*, 5-2.

It's funny, because I think they mailed out something like 700 of these mail surveys, and they had this crazy response rate of like 70% – a really good response rate. And so after that, when it came back that they wanted more information about how the data were being used, and they wanted – they felt like the didn't have much interaction with the people leading the project. So I tried to go out and interact more with them. So when I would have these meetings I said, "ok, so I just want to let you know that one of the things that came up in the mail survey is that you felt like you weren't having enough access to me." I'd see blank faces in the audience, and I said, "you remember the mail survey, right?" They're like "no, we have no idea what you're talking about." I was like, "you know, the thing you got in the mail that had all those questions about the sea turtle project, and then you responded?" They're like, "no no, we don't remember that at all." You know, and I kept asking, and they're like, "oh, yeah, yeah I sorta remember that." And it wasn't that long ago, right? So, it's just funny sometimes. I think they've got a lot of stuff going on and they don't – what seems really highly relevant to me, at the tip of my tongue is probably not so relevant and not at the fore of their everyday thinking as I think it should be, but clearly it's not.

I have my own personal research interest, mostly to do with sex ratios of sea turtles, because that's what I worked on for my PhD[3]. North Carolina is interesting – it's the northern end of the nesting range, so temperatures are a little bit cooler here, and of course temperature affects the sex of the turtles. So I'm very interested in finding out more about natural sex ratios of hatchlings produced and then how our management actions might affect those, whether it's having buildings on the beach that cast shadow in the afternoon that might cool down things[4], or putting some nests or beach nourishment projects where they actually put new sand on the beach to try to counter erosion – they do that in the winter – does the color of the sand affect the sex ratio of nests that are laid there the subsequent year? Things like that. So those kinds of things I'm really interested in. And I have set up specific projects with particular beaches where I've asked the volunteers to collect extra data, whether it's sand temperature data, or…. On one beach, I asked them not to move any nests. They are allowed to move some of the nests if they feel that they're endangered of being washed out by the ocean, but I asked them for a

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[3] See, for example: Godfrey, M.H. (1997). Sex ratios of sea turtle hatchlings: direct and indirect estimates. PhD Thesis, Department of Zoology, University of Toronto, Canada, 199pp.
Godfrey, M. H., Mrosovsky, N., & Barreto, R. (1996). Estimating past and present sex ratios of sea turtles in Suriname. *Canadian Journal of Zoology*, *74*(2), 267-277.
Godfrey, M. H., D'Amato, A. F., Marcovaldi, M. Â., & Mrosovsky, N. (1999). Pivotal temperature and predicted sex ratios for hatchling hawksbill turtles from Brazil. *Canadian Journal of Zoology*, *77*(9), 1465-1473.
Hulin, V., V. Delmas,M. Girondot, M.H. Godfrey & J.M. Guillon (2009). Temperature-dependent sex determination and global change: are some species at greater risk? *Oecologia* **160**: 493-506.
Godfrey, M.H. (2013). Turtles left out in the cold? *Current Conservation* **6.2**: 31-33.
[4] Mrosovsky, N., Lavin, C. and Godfrey, M.H. (1995). Thermal effects of condominiums on a turtle beach in Florida. *Biological Conservation* **74**: 151-156.

couple of years not to do that. Actually, that was probably the most contentious thing I ever experienced here, was asking them to do that. But I think in the end they agreed it was worth doing. So there are small projects I am interested in.

Actually that reminds me – we just started a new project last year, which was somewhat contentious also. I asked all the volunteers to take a single fresh egg from every nest as part of a genetics project here, with North Carolina, South Carolina, and Georgia. We're doing this multi-state research project, and there was some reticence on the part of volunteers who felt that sacrificing a single egg was too much to ask of them, that it was contradictory that we asked them to protect the nest but then we're also asking them to sacrifice an egg. But I told them that the information gained from that will actually help improve management, and that it's a short-term loss for a long-term gain. I think most of them are on board now with that. There's far less complaints about collecting those eggs than there was about not being allowed to relocate the nests initially, which I did several years ago. But those are the only two contentious things, everything else has been – all of the smaller projects have been much more straightforward – collect sand temperature data, collect sand samples, call us if there's a nesting female on the beach at night so we can put a satellite tag on it, things like that. All those have been great, and people have been really excited about them.

So, nest relocation is a very interesting management technique. Essentially, you have the turtles come, they lay their eggs, then they leave and they're done. They're done with the parental investment, they don't come back and check on them or anything like that. And turtles lay more than one nest, so in a particular year they might lay 4 or 5 or 6 nests. There's pressure to lay them above the high tide line, but not too far back, because the further you go back the more susceptible to predation are both the eggs and the hatchlings when they come out of the nest. So there's tension for the turtles between wanting to be above the high tide line but not too far. They do tend to scatter where they lay their eggs, and sometimes they're a little bit too close to the high tide line and it does get washed over. Some nests do naturally get washed away, even if they are laid far above the high tide line, sometimes hurricanes wash nests out, extreme tidal events, things like that. So nest relocation, some people use that as a way to mitigate that kind of loss. They'll look at where the nest has been laid, and they'll say, "oh I think for sure we're going to get a hurricane," or, "for sure that's below the normal high tide line, that nest is going to get inundated too much and all the eggs are going to perish, we need to move it further up the beach to guarantee that it's going to produce hatchlings." And that's fine, in certain situations that's fine.

The problem is, is that some people tend to move nests for other reasons. For instance, "oh, that nest is a little bit too close to that walkway, I think, and people might accidentally step on the eggs." Even though the nest is marked off, and has a big sign and nobody's going to walk over it, they still will relocate it. Or they feel like there are too many bright lights that might affect the hatchlings at night, so they'll move it down the beach. Or, I've even heard rumors where people have auctioned off the right to have a nest in front of your beach house, if you give us so much money, we'll relocate it in front of your beach house, although I've never been able to verify that, and it's always the case of, "well, I heard at such and such a beach they do this." But I also think that just the act of relocating the eggs sort of plays into the desire for certain volunteers to feel like they're doing as much as they can for the eggs. So it's sort of, for them it's a really pleasurable thing to do. Not just to find the nest and mark it off, but actually to relocate the eggs, because you feel like you're actually doing more to protect them, even if you don't necessarily have to relocate the eggs.

The major concern I have with relocation is that if we move the eggs back up the beach, further up the beach, you tend to move them into warmer areas. We were talking about the sex ratio stuff, that the higher up the beach you go, the warmer it is, so you could actually end up causing an influence on sex ratios and producing more female hatchlings. I wanted to get at this and find out if that was really happening. But, it was confounded by a…. So, I wanted to do this on one island, but unfortunately I couldn't do it there because they were doing a beach nourishment project. To combat normal erosion some places, what they do in the winter is they pump up sand from the ocean floor, and they place it back on the beach. That's why they call it nourishment, they just extend it out, and a lot of times the sand that they put on is not the same color or quality of the sand that was originally on there. The question was, that could definitely have an impact on sea turtles, whether it impacts their ability to produce hatchlings from eggs laid in that sand, or it could affect temperature and therefore sex ratios. So I put the relocation-affecting-sex-ratio question on hold and I just wanted to look at nourishment and its impacts. I actually kind of had to do this, because when I came to this job, the guy that was temporarily in the position that I have now, he had set up a research project the year before I got here to look at those things, and had signed a contract with the county to provide money to do the work. So when I started my position, the research project had begun and I had to see it through to the end. It was a 6 year project, with 3 study years and 3 follow-up years, so I thought the best way to do it would be to reduce the number of variables in the research. And one of those variables was relocation. So that's when I said ok, for 3 years there will be no relocation on this island. And that's when some of the people got very upset about that.

When I told them initially that we were going to do that, some of them said "ok," and some of them said, "no way, you're not telling us we can't do that, because you're forcing us…," essentially they said, "you're forcing us to kill some eggs, because we know that some of them will be washed away." So I tried to explain that, you know, the study is to look at the impacts of nourishment, and if nourishment is having a negative impact on sea turtles we want to know, because there's going to be a lot of nourishment in the future. If we're going to manage nourishment in a way that minimizes impacts, we need to know how it impacts turtles, and relocation is just a variable that we need to control. Unfortunately, there was a lot of contention around that. Some of the volunteers actually quit over that, I think two or three did. None of the beach coordinators quit over that, I don't think – no, none of them quit over that.

The first year, fortunately, not a single nest was lost to high tides or overwash or anything like that, so it was pretty lucky that that worked out that way. In subsequent years, definitely some nests were lost due to high tides, and there were lots of phone calls as a result of that. They would call and say, "I'm standing right here, the water's coming up, please let me move them," and I would say, "no, you can't, we had agreed to do this." They said, "oh, but you're condemning the eggs to death." And I tried to explain that it's for a larger purpose, but it was a bit contentious, there was a lot of pressure and strain around that. A few times the volunteers just went ahead and relocated eggs even though I told them not to, so again that led to more conversation about cooperation and following instructions and things like that. But I think that the information gained was really useful, very useful and influential. And subsequently they were all allowed to go back to relocating as many nests as they wanted to.

One of the things that I was concerned about was that some of the volunteers would be overly cautious and end up relocating far more nests than they should have. And they haven't actually, I was quite surprised, pleasantly surprised that they didn't, and they've also been very cautious about which nests they relocate and which they don't, far more than they used to be. So in the past the state average for number of nests relocated was about 60%, over time it's dropped to about 20, 25%, depends on the year. Which is a huge change. Of course, I realize that some people probably still relocate that don't actually mark down on their data sheets that it was relocated. Which is fine, I just have to accept that. But I'd say by and large, most people understand why we want to use it, why it's a usable tool, but why it should not be abused and overly put into place, how it could have negative impacts that way. And I think, over time, people have gotten the idea and they support it and they now take that into account in their decision making process when they come upon a nest in the morning.

And what we learned about beach nourishment – essentially, it's completely intuitive that the darker the sand material that you place on the beach, the warmer it's going to be, because it's darker so it absorbs more solar radiation. The question is just how warm does it get, and it gets on average about 2 degrees Celsius warmer at sea turtle nest depth[5]. Which can definitely swing it from mostly males being produced to mostly females, or all females being produced. So those data were fed into new state criteria for beach sand material that can be placed on beaches during re-nourishment processes. Of

[5] See Holloman, K. T., & Godfrey, M. H. (2008). Sea Turtle Monitoring Project Report Bogue Banks, North Carolina. *Raleigh, NC: North Carolina Wildlife Resources Commission*.

course it's not perfect, I would like some of those rules to be a bit stronger, but they definitely did put into those rules the types of material that you can place on the beach can or cannot, or some types of material can or cannot be placed on the beach including the very dark material. So those data were quite useful for that. And then in terms of what I was curious about, overall if you didn't relocate any nests how many nests would you lose in a particular year, and it seems to be about 20% of the nests get washed away just naturally. So I use that as a rough baseline for how many nests should be relocated, more or less. So that's my rule of thumb essentially. If people are relocating between 20 and 30% of their nests per year, I think that's acceptable. If it's greatly above 30% then I start to wonder what's going on. So those two things have been really useful for me.

Sea turtles are very resilient, and their eggs are too. Essentially as long as you're careful, and you do a good job relocating the eggs, you can get a really good hatch rate. In terms of the actual fitness of hatchlings that are produced, we don't really know. There have been some studies in Florida that seem to suggest that there might be an impact on fitness, but it's very difficult to tease out that kind of stuff. By and large the way I take it is that, if you know those eggs are going to be washed away, and you're going get 0% success rate, then by relocating them and getting less fit hatchlings, you're just better off, period. However if it's a nest that still would have produced hatchlings had you not relocated it, then you really should not have relocated it. And that's the way everybody's supposed to approach it now. And it's funny, you know it's one of those things that I've been saying ever since I started here in 2002, and I used to think, "why am I saying this again?" And now, it's funny when I start to say it to volunteers, they just they parrot it right back to me, and they know it by heart now. They do apparently accept it, and also I find that quite gratifying actually, that they have come on board and accepted that.

We have an annual meeting every year for all the beach coordinators, and then anybody else that can come is welcome to come, but usually it's just the beach coordinators that come. So I presented those data, I think I presented four years in a row, the same data, and I think they finally got sick of it, and don't want to see them again. But I would present it every year to them in that manner. I think they were sick of it by the end. One of the learning things for me has been – we have this annual meeting every year, where everybody comes as a way for them to talk to me, for me to talk to them, for them to make contact with each other, and training and new ideas, but it's a long day. It's 9 to 4, and there's a lot of information usually covered. So I used to think, "oh, well I told them that last year, why do I need to say it again?" But, in the context of all the information that they're getting, probably a lot of it is not retained easily, so I think repeating simple messages over and over again is a good thing. It allows them to retain and it's more likely for them to retain it if I say it again and again, than if I just say it once and say "oh, well I've told them, they should be able to remember," because it is a lot of information in one day.

I have these great visions of myself being a super researcher, but in fact I have no time really to do research, so what it's ended up being is that I tend to collaborate on projects with other people, and I try to facilitate the research as much as possible and live vicariously through other people doing research. So a lot of students are doing stuff, some of the National Seashore wanted to do a project, the same temperature project a couple years ago, so they'd been working on that, things like that. So I'll facilitate that as much as I can, but I'm rarely the lead on any actual research projects myself. That nourishment study[6] was the last time that I actually did my own research project, and that ended in 2006, so it's kind of sad actually. I'm all for research being done in the state, and so there are various people that are interested in doing work, and doing work here. Some I'm more closely affiliated with some of the research that's being done, I'm actively involved on some of the projects – other projects not at all. It's just they're doing it, I just make sure that they don't do anything they're not supposed to do and that's it. I haven't counted up, but there's probably, I don't know, a couple dozen projects going on at any one time in the state involving sea turtles. Which is great, I'm all for it – if we can facilitate that, I'm happy to do that. But in terms of my own personal research, unfortunately the more time goes by, the more I'm realizing that I am not the – that's not my main role in life right now, it's managing the project, that's my role. My job is to keep everything running and make sure everything is functioning the way it's supposed to function, and the data keep coming in, and you know so we're living up to the minimum requirements of our cooperative agreements with Fish and Wildlife Service and the National Fishery Service, and all the volunteers are doing the minimum things that they're supposed to be doing and that's pretty much my day-to-day job. Since most of the time I actually sit in my office and read email and talk on the phone, it's – to actually do the management of the turtles I have to manage the people who are touching the turtles. So I'd say I'm working through volunteers to get that stuff done.

When I got here in 2002 – I live in Beaufort which is on the coast. It doesn't have access to oceanside beach. We've got a big estuarine area in front of us, so the nearest beach is Beau Banks, it's probably a 15 minute drive away. But when I started here, this research project was already underway, and so we had a technician that we hired that would go every day on the ATV and check for nests on the entire island, and when she needed a break I would go out and do it, so I was very actively involved in some of the day to day monitoring on the beach. And initially I thought, you know, it's really a pain having all these volunteers here, it's really a lot of work. It would be so much easier if I could just hire one or two people to do all the work, and then just deal with only one or two people. That was my initial reaction coming from other projects. Then over time I realized that actually it's – you know, no, that's not the point. The point is to engage people, to have them actively involved, because the more involved they are, the more ownership they have and the more they end up doing and the more they end up actually getting done. Whereas if you had two paid temporary people, you know, what do they care when it's 5

[6] Ibid.

o clock quitting time? But if you have homeowners that actually live on the beach, or really care about turtles and the habitat, they'll be out there 24-7 making sure everything is ok. So I really like the idea of having people who live in the habitat be responsible for taking care of the habitat and that's – personally, I think that's the way it should be. So I think it's really super that local homeowners or people who live nearby, they're the ones that are out there every day, checking on turtles, checking on the habitat, trying to clean up garbage, things like that, reporting on illegal activities whatever they are – if someone's put up illegal sand-fencing, or things like that. Keeping an eye on stuff, making sure that people pick up after their dogs, poop and scoop, things like that[7]. So I think that's really great, and the more I see it and the more I work with it, the more I realize that that's really… that's how you get the most done in this kind of stuff, is getting people who are invested in it and want it done. Getting them involved and letting them participate.

I came into this job understanding that one of the objectives of the state agency is to involve the public in management and education opportunities and things like that, in interactions with wildlife, so I just took it as straightforward that having people involved in the sea turtle project would help me to that objective. There's that overall objective there. And also just, with the extent of the coastline we could not get these kinds of data without people's help and willingness to volunteer, we couldn't possibly pay people to do this. So it's a way of getting access to data that otherwise we wouldn't get. Those were originally my main two objectives. I haven't really thought about it that much since then, like what my objectives are now, except try to keep everybody happy and fulfilled as much as possible and excited about it, and interested in continuing to work with us.

Volunteers definitely play an active role in collecting data in North Carolina, and that is in part for logistic reasons. But also, the mandate of our state agency is to try to get the public involved as much as possible in management and wildlife conservation and things like that. This agency primarily is for wildlife management, in the traditional terms of game wildlife – bears, deer, things like that, fish and fishing. So they're very interested in wanting people to go out and do those things, and interact with the wildlife, mostly in a very specific kind of way, which is hunting or fishing. Although in the past decade or so, watchable wildlife has become much more prominent, especially as the state's population becomes more urbanized and less interested in going out and hunting, and more interested in say, bird watching, or bat watching or things like that. But it's always been a primary objective to get the public wanting to go out and interact somehow with wildlife. This is a perfect fit, by getting the public who's so interested in turtles involved.

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[7] For more on volunteers' contributions to turtle management in North Carolina: Cornwell, M. L., & Campbell, L. M. (2012). Co-producing conservation and knowledge: Citizen-based sea turtle monitoring in North Carolina, USA. *Social Studies of Science*, *42*(1), 101-120.

But what the agency thinks about all that is evolving. Traditionally it was definitely the hook and gun approach to involvement, where people are hunting and fishing – proper stewardship of the resources so that the resources would continue to be there to be hunted and fished, as they thought that the public largely wanted. But as the state becomes more urbanized and people are less interested in going out and hunting or have less opportunity to, they're becoming more interested in things like watchable wildlife. The public is, anyway. And our agency has to come to grips with that, so it's an evolving process, we're – I know that our agency has done a bunch of survey work trying to find out what the public thinks the rules of the commission should be or state agency should be in terms of wildlife. Should it be primarily for hunting and fishing? Should it be primarily for watchable wildlife? Should it be both, and in what cases? And it's definitely in flux right now. It's still pretty heavy towards management for resource extraction – hunting, fishing, things like that. But the public wants to see more non-extractive kind of interactions with wildlife. So it's going to change – it is changing and it will change a lot more. So I don't know officially what the stance is of my agency because it's changing so much. They're trying to embrace both right now, probably equally.

But probably turtles wouldn't come to mind first off as watchable wildlife, it would be more like birds, right? And we recently established three separate birding trails in three separate geographic regions in the state, with lots of fanfare and trying to get people out to look for birds. So birds are pretty high profile right now, for watchable wildlife. But there are others, frogs – there's a new frog call survey that's been established where people are encouraged to participate, to go out and listen for frog calls at night and report what they hear. Turtles have always been traditionally pretty high profile at least on the coast, and that's – I think it's the longest running volunteer wildlife program in the state, just because it's been so high profile. Everybody likes turtles. Well, not everybody, but mostly everybody does.

I'm not that well versed in some of the other aspects of wildlife management, but I know for the sea turtle stuff, I do think there's a definite role for the public to play in improving management at various levels. I try to take suggestions and comments into account. Like when people come up with new ideas, I try to evaluate them and integrate them if they work in a way we can manage them. And I try to get some of the different beaches to participate in research, to be more active towards better managing turtles. And, it might be as simple as suggesting a better data collection form, or it might be as intense as suggesting a completely new way of changing the way we interact with turtles on the beach or something like that. But from my perspective, if people come with constructive suggestions then I'm very happy to take those into account and try to work with them to evaluate them, to see if those are good things to implement or not.

One thing that comes up quite often is how can we better estimate when the hatchlings are going to come out. So, the turtles come, they lay their eggs. People go out every day, look for the fresh crawls, verify the nests are there, put the stakes up, keep track of everything. And then after 50-60 days the eggs are going to produce hatchlings, and the hatchlings are eventually going to come out. And so they start their vigils, their nighttime vigils of watching the nests to make sure the hatchlings get to the water safely. But the emergence really varies between 50 days to 80 days post-laying by the female. And it's usually temperature dependent, but it's not as clear-cut as that, because you do get rain storms, tropical storms, things like that that can change the temperature briefly, but how do you integrate that across the whole length of incubation? So oftentimes these people suggest, "why don't we use a stethoscope?" That's probably the most common one. People want to use the stethoscope to listen to see if they can hear the hatchlings coming up. Which I don't encourage because, I've tried it myself, and you can't – I mean you hear the ocean really well, the waves crashing, and you don't really hear much else. They're convinced that they can hear it. So I let them do that but no one's been able to show conclusively that they can anticipate exactly 24-36 hours ahead of time when the hatchlings are coming out based on the stethoscopes. So I'd say that's an example where a suggestion hasn't really worked. I don't discourage them from using stethoscopes but even though they can say, "oh we anticipate it's coming out in 36 hours," I won't let them change the way they do anything else based on that.

But in terms of positively changing the way we do things, for instance with the stranded turtles that come in – a lot of times it's the volunteers that will find the turtles that are injured, and drive them from the beach to the turtle rehab center, and they've come up with a lot of different ways of trying to minimize stress on the turtles. And so one woman did a lot of research on it and she found another group in the US that made sort of like a harness, a flexible harness to restrain the turtles to keep them from flapping around too much and maybe injuring their flippers. And also it would reinforce the carapace if it was broken from a boat strike or something like that. So she contacted the other group, she found out about the way things were made, she asked them for a sample, and then she found somebody else in the state who was willing to make it here at a reduced price. So they just made them, and they distributed them amongst the different beaches that tend to get a lot of live strandings. And so that's a new method for them to transport turtles from one place to another, which is great, and it appears to work better and so I was totally encouraging that. Some of them had also suggested using eye drops in the eyes of some turtles, especially on long drives, long transport times, to keep their eyes from drying out, which again is a great idea so we've tried to institute that statewide. It's mostly small things like that, but when lumped together, they really do help improve the way we try to manage stuff in the state.

Volunteers also like to collect their own information sometimes. For instance they love to collect information on the width of the crawl of the turtle in the sand when they go in the morning, so oftentimes they'll report that. We have a listserv that people send out emails almost every day when they find new nests and oftentimes they'll report a crawl width, which is a data field that I've never requested. Nobody has requested it in the state, but they've taken it upon themselves to do that. I'm not sure where that information goes, I've never really followed up on it or asked anybody about it, they've never really submitted it to me in the past, and definitely now with the online system it's not coming to me at all. I'm not really sure why they do that. I haven't really pursued it because I don't think there's anything wrong with collecting those data, that's fine if they want to do that. But I don't want to have to tell them that I think those data are not very informative, because it's not clear how they're measuring them, and there's no standardized technique of measuring that stuff.

They have also been collecting a lot of the data on how many beach umbrellas are left out overnight, and what it looks like on the beach, and they try to photo document that. This is more when the turtles are nesting… the volunteers themselves are so proactive when it comes to when the hatchlings are going to come out, they pretty much clean the entire beach in front of the nest ahead of time. As part of their babysitting job they keep everything set, like not even stray leaves will be on the sand. They're very protective about that. But for when the turtles are nesting, I've worked really hard to try to get the towns to pass local ordinances about leaving beach furniture on the beach at night, or if when people dig holes in the beach, trying to get those filled in at the end of the day so turtles don't fall in, or the turtle walkers themselves don't fall in at night or in the morning. So the volunteers help with that kind of stuff too, which is great – from my perspective that's great, because I can't work at a state level to try to get that done, I've tried in the past and it was clear that it was going to be impossible, so working at the municipal level is much better. So they've taken it upon themselves to do that. And I guess there's probably a handful of towns that have ordinances like that now, which is good – it's not the entire state, but it's probably about a third to half of the state that have ordinances now.

It's become abundantly clear in my experience that management is not just a question of what works best, and implementing that, because there's all the political and social and all that background and baggage associated with things that you have to take into account. So, in a perfect world it would just be doing whatever works best, but of course the world is not perfect, so I try to negotiate to get as good as possible, the best of a bad situation sometimes. But it's not going to be perfect by any means. You know, if I had complete authority and control it probably wouldn't be that way. But that's just the way things work, right? So when situations come up I try to evaluate them on a broad scale, and try to negotiate for what is the best I can get under the circumstances, which oftentimes is not the ideal.

There's ideal management on paper, right? And then there's what actually happens in the real world. So if you look at, for instance, the loggerhead recovery plan that's like 400 pages long[8], in an ideal world all 396 actions to help recover loggerheads would go into place, but there's no way in hell that that's going to happen. For various reasons. So it's the ideal, but when you actually get down to trying to implement them, you have to start negotiating with people what's acceptable, what's not acceptable, what can you get, what's the most you can get, things like that.

And I think overall it's important to get across to the volunteers that management is an evolving thing, and that it's not static, and that there's lots of things that aren't really known that well. So with more information and more knowledge, hopefully we can improve things and do a better job at managing them. That's getting the volunteers to get involved and behind new research projects which should increase knowledge and therefore lead to better management techniques. It would be great to get them on board, to understand that it's not just, "we've always done it this way, we'll always do it this way," but it's an organic thing that's always evolving and changing, trying to become better. I think that's a good way to get people thinking, and I try to get them thinking that way, although sometimes people are reluctant to change, as we all know.

For example, this eggshell-DNA project. It's a joint research project – North Carolina, South Carolina, and Georgia – where we're looking at trying to get DNA fingerprints for every single nesting female loggerhead in the three states for this northern recovery unit[9]. Traditionally the way you would do that is you would send people out at night to try to intercept the females as they came up to nest on the beach, and then they would take a small piece of tissue from the flipper. But it's really hard to do that, and takes a lot of time and energy. So there's this new way – if you get a fresh eggshell that's been laid within the past day or two you can actually get some of the female's cells from inside in between the different layers of the shell, and then that's enough to get you a DNA fingerprint. Presumably if you collect a single egg from all the nests, you'll be able to match up which nest came from which female. And then you can have this nice map of both location and time of where the females are nesting across the nesting season, because they will nest four, five, maybe six times during the season in different places. So initially, the reason we wanted this is because it's much better to know exactly how many females there are, just not how many nests, and how faithful they are to different beaches or unfaithful, and then how often they're coming back over time – do they come back every second year, third year, or fourth year? Things like that. And then, can we also

[8] National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2008. Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (*Caretta caretta*), Second Revision. National Marine Fisheries Service, Silver Spring, MD. 325p.

[9] Shamblin, B. M., M. G. Dodd, D. A. Bagley, L. M. Ehrhart, A. D. Tucker, C. Johnson, R. R. Carthy, R. A. Scarpino, E. McMichael, D. S. Addison, K. L. Williams, M. G. Frick, S. Ouellette, A. B. Meylan, M. H. Godfrey, S. R. Murphy, and C. J. Nairn. 2011. Genetic structure of the southeastern United States loggerhead turtle nesting aggregation: evidence of additional structure within the peninsular Florida recovery unit. *Marine biology* (158):571-587.

link things like reduced hatching success to individual females – maybe there are just some females that aren't as good at producing as many hatchlings as others, they just have a lower egg fertility rate or something like that.

These are the kinds of information that we wanted that would help us better manage, help us better understand population dynamics, and help improve management overall. But there was resistance to this, because some of the volunteers felt it was unreasonable to sacrifice a single egg out of 120 in the total nest for this, they didn't feel that the knowledge was sufficient. I think we were able to convince most people. Some people did resign because of it, and that's fine, I didn't expect everybody to agree with it wholeheartedly. But by and large I think the majority of people agreed. And then, on our website, we link the genetic data with the nest data. So for a particular nest, they could click a button and then a map would pop up, and people could see automatically where that female nested throughout the season – whether she always came back to the same beach, or where she went. And I think having those data available, people really got on board with it, and were very excited about the project, and had a better understanding now of why these data are so important. This has been the second year, and there has been absolutely no resistance whatsoever. In fact people are calling and saying, "when are we going to get the data from year 2? What's going on, how can I find out more?" So it's been a really good way to get them involved and excited about research and they can see directly how the samples they've collected – you know, what kind of information that produced and how useful they are. So I think it's been a really good for everybody. Good for us, good for them… and I hope they see that they're a part of it, and they deserve to be recognized as playing a role in it, and that they're part of the research team. It's a good question though, – I haven't specifically asked them if they do, if they feel like they have ownership in the project. If they feel like they're part of the project or not. That might be a good thing to do in the future. Because I think they should, and I'll reinforce that with them – that it couldn't be done without them and they're part of it, and that they own the data as much as anybody else.

One of the surprising things for me coming here was how, when individual people are working on specific beaches, how parochial their view is – it seemed to me that they had a hard time understanding that they were working within a larger… that their turtles were not just their turtles, they're part of a larger population and that they're actually working within a larger system and a larger network, and that everybody's working toward the same goal. So the broader view I think was missing in a lot of cases. And now, with some of the data coming back showing that turtles are nesting one time in North Carolina, another time in South Carolina, and then again in Georgia, they're seeing that these turtles are sharing, they are moving around a lot and the different states and different beaches are sharing the same individuals and that they're all part of a larger project and larger network, and we should all be working together. I think that's, for me that's been a really good thing, to get them thinking more about the bigger picture.

I've seen changes in their attitudes in the way they talk about all this. I haven't really seen much change in the way they act, I mean, they're all super protective of their turtles, and I don't think that will change. But they do talk about how it could be that this turtle nested down 50 miles away two weeks ago, and maybe it'll go north after this.... And for instance, they talk about sometimes in some of their nests have a low hatching success and they don't understand why, they say, "oh, but maybe we'll find out at the end of the year when we can look at the entire map for this female, and look at the hatching success for all her nests, maybe we'll know if she just has lower success overall." So I do think they are thinking a bit broader about this and how these data are going to help them maybe put their individual nests into a wider perspective. I see that quite commonly, where they say, "oh yeah, once we get all this DNA stuff then we can start talking about this stuff," which is great.

And then there are things that they do all by themselves. I just saw this news release yesterday, that one of the sea turtle volunteers in Wrightsville beach was awarded – Wrightsville beach is the beach town that's next to Wilmington, which is the largest city on the coast in North Carolina. So it's a pretty big beach, Wrightsville beach is this huge built up beach, very densely populated, and they have an active sea turtle volunteer program there, over a hundred volunteers. But it's so built up and there are so many lights and so many people on the beach at night, that they actually get very few turtle nests. Anyway, one of the sea turtle volunteers there, during her daily morning patrols, thought, "you know, while we're out here, we should actually pick up some of the garbage." And so she organized this garbage patrol in addition to the sea turtle volunteer stuff. It's morphed into this huge thing where they now collect garbage, they sort through it, they figure out what's being thrown out, and they try to trace it back to where it's coming from. They have contacted different hotels or restaurants or other places that they think might be involved in some of the release of the garbage, try to work on ways to reduce the number and the amount of garbage going on the beach[10]. And this is all done grassroots level, I had nothing to do with it. So the woman who is the primary instigator behind it just won the volunteer of the year award from Wrightsville beach for all the work that she's done in the past on trying to control the garbage there. Which is really – that's awesome. I mean, that's perfect. That's what – they are potentially quite powerful, these volunteers, and that's what they should be doing, is exploring avenues where they can exert some of their power and get stuff done. So I think that's great. I was really happy to see that.

There's one group down in Topsail Island that filed a lawsuit against another state agency, the Division of Marine Fisheries, to change their practices to reduce bycatch of sea turtles in their state waters. It's one of the local volunteer groups – every beach or island has a volunteer group, some are more organized than others. This one's pretty

[10] Wrightsville Beach Keep It Clean project: http://wbkeepitclean.blogspot.com/p/history-of-kic.html

organized – they have their own non-profit group, their own website, and they run one of the rehab centers in the state. They partnered with the Duke environmental law clinic[11], and filed a lawsuit against the Division of Marine Fisheries in North Carolina for allowing large-mesh gill nets to operate in the state without having proper permits, because there is high potential for bycatch of sea turtles in those gill nets. And it's resulted in them reaching a settlement agreement, which specified a bunch of management changes to the gill net fishery including reduced efforts, closures, time area closures, things like that. This has definitely has greatly impacted bycatch rates. And depending on who you're talking to they would say that that's – well, it's definitely a major change, some people would say it was for the good, some people would say it was for the worse. But that definitely jumps to mind as an example of something happening, that the volunteers did themselves. The volunteer coordinator for that group, her name is Jean Beasley, she's been involved with the turtle program for more than 20 years, and I think she's always been aware of these kinds of issues and she told me that she just decided that that was the time to do it. But, she had been thinking about it for a long time. She and her group did it, they were not being pushed by me or anybody else to do it. They did it all themselves.

These particular actions were in response to observations not really by our volunteers per se, but by the onboard observer coverage in the state, and reports that had been floating around for a while. It's something that everybody's sort of known about, and been concerned a bit about, but it didn't really coalesce into a major issue until this group put it all together. They put together quite a lengthy document describing the issue and arguing why it was a problem, and who was at fault, and how the management could be improved, things like that. So they were the ones that brought it all together. I don't think it was any particular work of the volunteers per se on the ground collecting data from stranded turtles that culminated in that *per se*, but the actual work of putting together the litigation was largely through the volunteers.

Ultimately, with all of this, I would like their actions to be based in the best understanding possible of sea turtle biology and ecology. There are some things that volunteers do that just don't make sense to me, and I try to dissuade them – if it has a negative impact or a potential negative impact I try to dissuade them. But it takes a long time because they've been doing things their way for a long time. But that's my goal – to try to get them, when they make decisions, to do things with a better understanding of what the potential impacts may or may not be down the line. And they're getting a lot better. I should say that they have changed quite a bit over all. Remarkably, when I started maybe in the first year if you had asked me at that – what are the chances for them to change their attitudes and their activities? – I would have said pretty slim. But they have changed quite a bit over time. So I'm happy about that.

[11] Environmental Law and Policy Clinic, Duke University School of Law

Bill McShea
Smithsonian's Conservation Biology Institute

Ecology that's rough around the edges

I met Bill McShea in 2000 when I was working in the Education Office at the Smithsonian's Conservation & Research Center in Front Royal, Virginia (now the Conservation Biology Institute). Bill had helped design a Forest Biodiversity Monitoring Project for schools in Northern Virginia, and I was helping support teachers with inquiry-based training sessions around the scientific protocols that mirrored Bill's own fieldwork. Although this set of protocols was never meant to yield data for scientific use beyond the school grounds, Bill still wholly invested himself in inspiring the teachers with his energy, charisma, and tales of his research in exotic locales. I worked most closely with Bill's large crew of field techs and interns, who helped extensively with the on-site Earthwatch program in the summertime. At the time, Bill was in the final year of offering his this Earthwatch project, and I remember conversations about whether the project was worth his time and the time of his technicians (although I never failed to see him enthusiastically dominating the weekly volleyball tournaments). I was surprised to hear later that Bill had started up several new volunteer-based projects, albeit without the residential aspect of Earthwatch. Over our three conversations across 2009-2011, Bill spoke about his history with Earthwatch, and the evolution of three new initiatives: Appalachian Trail camera trapping, a butterfly survey, and a warm season grass restoration project.

I am a wildlife ecologist with a strong bent toward conservation or applied management. I work primarily with mammals, but that includes the ecosystem approach where you're looking at the interaction between animals and plants, and human impacts on those systems. And usually I'm looking at such a broad landscape that I can not do it all myself, and I need to have a lot more hands out there and citizen scientists are a good alternative to trying to support four technicians or something like that.

Volunteers for me come in many forms, and I don't know whether you call an intern a volunteer because they're paid twenty dollars a day. Those people have been around forever. But then there are people that are real volunteers, and some of those are short term and some are long term, and it's all mixed up in my mind.

I've got a lot of projects out there. Aside from having interns, from day one, Earthwatch was the first formal volunteer partnership. I did Earthwatch here [in Virginia] for nine years, and I did Earthwatch for two years in China, so it was 11 years of Earthwatch people. Some of those years, for three or four years we did nine groups. For a number of years we did six groups. In China we did four groups each year. That's a two-week stint, for each of those, so I did a lot of that.

It was so long ago that this all started. The president of Earthwatch came to CRC[1] for one of these general tours. They saw the white-tailed deer radio tracking research that was going on, and they told the graduate student who was working on that at the time, Georg Schwede, "this would be great for Earthwatch people to do." And he said, "what is that? What's the advantage of that to us?" The advantage came out to, if you could put up with six months of volunteers you could get one year of a technician. Because it generates enough extra money that you could afford to keep around people that really know what they're doing. And you *can* get some extra data collected. So Georg came to me as far as…. I was a little more organized than he was, so I was more willing to say, "we just have to do this, this and this, and we have to make sure this is covered and that is covered, and we can do this and…." Then Georg left after a year and I just kept doing it.

Georg's a deer guy. He's now at WWF in their international programs, but he was originally doing the deer research here. He and I started a deer/small mammal/acorn thing. We had built a bunch of grids – some of them we fenced the deer out, and some of them we didn't fence the deer out, and then we just recorded over a twelve year period how things changed in some places and didn't change in others. We did the birds and the small mammals and the plants and the acorns. Go around to the mast collectors and collect the acorns, take them back, count them and weigh them. It's easy for volunteers to do that. You just can't make them do acorns every day of the week. You have to say, "today we're going to count the *hickory* nuts," and that's enough variation for them to say, "wow."

We had to count the deer around each of the grids, and that stuff had to be done each year at a certain month, a certain way. So, the volunteers were involved in different things – if it's June, we're mist netting. If it's August, it was small mammal trapping. And while they're doing that, you just fill them in with other things. You say, "well, we have nothing to do today, so why don't you guys radio track these deer – we've got these two interns over here radio tracking deer, and they could use some help, so go help them." Or, just fill them in on other projects.

And then that results in the usual kind of publications. Any publications you can find on the deer-small mammal, or deer-bird interaction stuff from here, it's all based on that volunteer data[2]. The first research project, we started out looking at if preventing deer

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[1] Now called SCBI, the Smithsonian Conservation Biology Institute was formerly the Conservation & Research Center.
[2] See, for example, McShea, W. J., and G. Schwede. 1993. Variable Acorn Crops: Responses of White-Tailed Deer and Other Mast Consumers. American Society of Mammalogists **74**:999-1006.

from competing with mice for acorns, do the mice populations increase or have less fluctuation? And so it was a matter of fencing the deer out from some mouse populations. You can answer that – mice can respond relatively quickly. Boom. Yes or no. They respond, or didn't respond. While you're doing that, the vegetation is growing up, and now you can say, "now we've had three, four years since the deer have been in here, and there's a lot more vegetation in here," you know, "is this a significant difference from the outside?" And then once you have that significant difference in vegetation, does that have ramifications for the birds? Because they're so closely tied to that understory vegetation. So, to answer the bird question it took nine or ten years. But you start out with these smaller questions, and try to get them answered first while you're heading toward this bigger thing. But then once we got the bird question answered – that was nine or ten years – there really was no reason to mist net birds anymore, or no reason to measure the vegetation any more. So we're not going to keep doing it, and we stopped doing it.

For the China Earthwatch projects, we're working with bears. We had some bears that were being radio collared and a graduate student at Virginia Tech was doing that work. So the volunteers would go and help do the radio tracking and then count acorns, and, and look at scat, and measure trees. And then that morphed into doing a survey of the whole province. It was travelling around the province, stopping in a village, interviewing people – finding out where there might be bears and going to that site and doing a survey, doing a transect, and looking for sign. Looking for sign is a very tedious process, so, one person could not do that project. It needs six or seven people, looking at every tree along a transect line. So, there may be one graduate student who's receiving a salary and five Earthwatch people who are helping him out. And that works out fine.

Two years ago I guess was the last Earthwatch in China. In 2000 when the deer project was ending I was swearing I would never, ever do another Earthwatch project for the rest of my life. But after a few years, then you're in China and the grad student in China says, "I need a huge number of people here," you know, "I need to have six staff," and, "we need a salary," and I say, "it ain't gonna happen. But, maybe there's another way we can do this. Bring these people over here…." So, I did it again. And probably at the end of those two years I said, "never again, never, ever, ever." And it's just always the trade off. At first you're really feeling you need that data and you really want that data, and after a while you say, "oh, this data's not worth the problems that I'm getting caused right now." [laughs]

Ecology, at least the kind of ecology I practice, is a very labor-intensive thing, and I could never afford all of the people that I need to do the work that I want to do. So there's always a trade off of, well, how exact do you need this work? And, how long would it take you to get somebody up to speed on how to do this work? And how much supervision would those volunteers need? A lot of times, I end up making a decision, ok, let's go for it, let's bring in some volunteers and try to work that equation in our favor, that we keep the tasks to things that they can complete, and we vary the tasks enough so that they feel like they're doing something new, and they always have to feel like they're doing something useful. If they ever get the sense that this is just busy work then you're dead meat. But usually that's not a problem, because usually it isn't busy work, it is something we need done.

I'm always working with two layers of volunteers: what you would call volunteers, people that are coming in for two weeks or volunteering on the butterfly project or the Appalachian Trail survey project, those people are paid no money and they're doing this out of… whatever. And they're being supervised by interns who are really volunteers themselves, they're just so poor they can't be a volunteer without some sort of monetary support. They're three-month people who need experience and have no clue what they really want to do with their life, so they're willing to volunteer at slave wages to learn new things. So I have two layers of volunteers going on out there. I have my interns who are really my long-term volunteers, and then underneath them are cycling these much shorter-term volunteers, and you get the long term ones up to speed as quick as possible so that they can start supervising the short term volunteers. And there's a cost to all of that, and you always have to figure, is this cost worth it or not worth it?

The cost is, do you believe the data that comes back in the door? [laughing] I mean, does it make any sense to you? If you're sending them all out to count something, and the counts come back just totally off the wall, then you start wondering what's going on. In my world, you never have enough time to do some sort of pilot, getting-ready thing, like, "let's try it with volunteers and let's try it without volunteers, and then we'll decide how's the best way to do it." No, you're usually out of time and have a short window of money, and you say, "ok, we're going to do it with volunteers and we're going to make this work, and we're going to figure out how much control we have to put over the volunteers in order to make sure that the data gets up to speed."

But, you realize some things right away, like you can't do a botany survey with volunteers. It just isn't going to work. The IDs are just too crazy, and there's no way you can verify that stuff. But if you're measuring DBH's[3] of trees, that's something that they can pick up pretty quick, and yeah, maybe the real measurement is 48.7 and they say 48.3, but in my world, that's fine. That's fine. So, there's a lot of holding the other end of the tape measure, and holding the clipboard while the botanist reads off the numbers, they write them down, and, that kind of stuff – there's always something they can do that is useful. If you're doing small mammal trapping, you know, it doesn't take long to identify a *Peromyscus*[4]. And since 99% of what we catch is *Peromyscus*, as long as there's somebody on the grid who know what it is when it isn't a *Peromyscus*, then you can usually just keep going with that.

[3] Diameter at breast height (a standard measurement of tree trunk girth).
[4] *Peromyscus leucopus*, white footed mouse.

We would usually have six or eight people in an Earthwatch team. I wouldn't do twenty people, I just couldn't handle that many people. I don't think they want to be in a crowd, gathering around, looking at something. They want to be doing something. So you don't want to have too many people, or there's not a job for everybody to do all the time.

And, I have different people doing different things. Some of them are just not capable of collecting the kind of data that you're going to need. There are people who can identify plants and there are people who can walk to the top of that mountain quickly and get you some data point. But there's a lot of people who are never going to make it to the top of that hill. And are going to think they're identifying plants and make total mistakes. And I have some staff that are very meticulous and are able to collect very careful data. I don't think that's so much different than the graduate students or the people I have working for me now. Every one of them has things they can do and things they can't do. And yes, they think they can do everything. But you find out what they can't do and you don't lose too much sleep over it, you just make sure they don't have to do that anymore, you just funnel them into something else. You just have to find out everybody's level pretty quick, and you just have to always be adjusting the job that they have, and then do things accordingly. So if I go back to these botany projects, if I'm going to do some kind of species richness thing where it's very important that every point is identified properly and, so nothing gets lumped that shouldn't be lumped and nothing gets split that shouldn't be split, then I've gotta have a meticulous person on that.

You have to realize that I also have eight projects going at the same time. In order to survive in this way, in this world, I have to have eight, ten projects going at the same time. And a good percentage of them fail. They just fail. And sometimes it's because we couldn't get the right labor at the right time. And from that you learn, "well, I'm not going to try that with volunteers again. This time I'm not going to do it unless we can afford the actual technicians to do something."

I don't know if I do this all intuitively, or if…. a lot of it is just, well, let's throw out a bunch of dice and see which ones roll up good. And, you know, now that I'm an old man I have a really good sense of what is possible and what is not possible. And I've probably become a little too jaded that I wouldn't try things today that I would have tried twenty years ago. But… so be it. I'm going to miss out on certain things by knowing that, well, that failed four times before and I'm not going to go down that path again. But, I think that the kind of ecology that I do is a little rough around the edges and that I can tolerate some of the errors that volunteers make.

For a lot of stuff I'm doing, it's a big impact that I'm looking for. Like deer browsing. There's a lot of deer browsing, and I'm not going to be publishing any paper that says, "there's 2% browsing here and 4% browsing over there, and this difference is significant because the variance is so small on each of those numbers." I'm publishing something like, "with deer there's 2% and without deer there's 80%. Look at this big difference." So when there's that kind of big difference, you can allow a little slop around that number. You know, so this person let a couple extra animals escape, and it doesn't make too much difference in the end. And that's my personality, so I can tolerate those Earthwatch people better. You know, if I'm looking at the home range of deer and I'm having them do the radio tracking, there's 60, 80 points that go into making a home range. And if the Earthwatch folks were responsible for 10 or 15 of those points, and they didn't get them exactly right, I'm not loosing too much sleep over that. Because I think they make mistakes in every single one of the animals, it's not like they make mistakes with some of the animals and not with others, they make it all the way across the board and it makes those home ranges more inexact than they would be, but the difference is either going to be really big or I'm not going to see it anyway. So it doesn't matter – I just have to be aware of what the project is and what the peoples' skills are.

And, I don't think I learned this – I think I knew this – that with volunteers, there's different rules for them than for an employee. That they do need some hugs along the way, they do need some benefits to them. I think about what I would do as a volunteer. For so many Earthwatch groups they give you a little square meter of ground and they give you a toothbrush, and they say, "ok, scrub this square meter for two weeks with your toothbrush, and see how far you can get." I just could not do that. I would have to have variety, you know, "this day's deer wrestling day, and this day is small mammal day, and this day is go count the acorns day." And, do I have enough of those kinds of different activities that I can keep things varied up.

And then, you find out that a lot of it is they just want to be with you, or pick your brain, or just hear your stories or … that sort of showmanship is part of the volunteer experience. You're not going to get too many volunteers who are going to come and clock in, and go off and do their job, and come back and clock out. They want to be with you. They want to be with the other workers, the young students, and they want to interact. And that's why they're volunteering, they don't want to be by themselves, doing their little square meter. So, I think for me that's an easy enough trade off.

The problems are that every volunteer has different expectations of what they're volunteering for. There's some miscommunication between the literature they get, or – they all get the same briefing, but some of them come away with, "I'm going to be able to volunteer when I want, and relax when I want," or, "I'm going to be working side by side with Dr. McShea all the time," or, you know, "he's going to be willing to read my unpublished novel." I mean, they just really want to be in with you. Well, half of them want to be really in with you, and half of them, this is some boondoggle that they're on and they want to, have drinks at lunch and get in their bathing suit in the afternoon and catch some sun. And those people are all in the same group, and it makes getting everybody on the same page, and having everybody happy at the same time, just… it's just too much [laughs]. It's just too much, because everybody's great the first couple days, or maybe they're nervous the first couple days, but eventually they realize that this is not what they expected, and this is not *their* fault, this is *your* fault that it's not what they expected. No volunteer has ever said, "I'm sorry, I misunderstood what was going on here." They always come across as, "you promised something that is not happening right now." And I've had so many wonderful, wonderful volunteers, and I can remember all the terrible volunteers, that's it. The wonderful ones are all lumped together in some amorphous mass of people, and the terrible ones stand out like a sore thumb. And you can only take so much of that before you say, "that's it," and, "I have to, for my own sanity, stop doing this."

But it depends on the personality of the person. Sometimes, you know, they don't want to do any work, then, you can pretty much as soon go, "ok, you're in charge of dinner. You just get ready, all during the day, get the dinner stuff ready, and make the dinner." Knowing full well that that's a one-hour job. But they'll make it seem like it takes them all day to get that organized. And they'll tell you about how many potatoes they had to peel, and how they had to go shopping for this extra thing, and how it occupied their whole day. And that's fine. Great. The harder people are the people who want to suck every ounce of energy out, every knowledge bit you have. For those folks you just have to rotate them around, you have to, because it's me, graduate students, and then technicians, and then the volunteers. So, I get together all the technicians and I say, "Joe is going to drive us crazy. So Tuesday Joe is yours, Wednesday Joe is yours, and you just put up with it because you know you only have to do this one day with them." And just move them around. And they're usually ok with that.

Earthwatch – I'll tell you, PIs sign up for Earthwatch – there's a lot of PIs who say, "I want to do an Earthwatch project," and they do one year then they never go back to it. Then there's others who have done ten, fifteen, twenty years, and who continue to take volunteers, because there's just two types of personalities out there and it's just such a drain that you can't do it. And then, you know, from the volunteer point of view, the more they see your whole life, the more they love that. You know, they LOVE coming over to the house and having dinner with the wife and the kids, they LOVE that, or you know, you barbecuing some hamburgers for them. They do not want to be treated like this is your job and you're going to do this, and then they can talk to you between these hours and that's it. Everybody wants to feel like we're all on the team and we're all working together and I don't make any boundaries between you're part of my work and you're part of my social sphere. So many of these people write me and send me pictures and Christmas cards for years after, and it's hard for me to even remember, what group were they in or what year were they here, or all the interns. You know, this is twenty-three years of interns with four or five here at all times, each here for three months. That's so many interns and they always write and say, "how is everyone doing?" and I have to say, "well, who is everyone to you? Who do you overlap with?" You know, I just have no idea what year you were here, and who you went with, and, that's just the way it is.

Sometimes I don't make time for the volunteers, sometimes I lose volunteers because I didn't spend enough time with them. I tend to say yes to too many things, and then scramble to catch up with all of those pieces. There's a lot of researchers here at the Smithsonian and most of them would not touch a volunteer with a ten foot pole. It's just not something they're going to do. It's not worth the social effort – you have to be a person who enjoys talking with people, who enjoys – you know, they may drive me crazy, but still, look, every two weeks I'm explaining and the same thing over and over again, and I'm trying to learn new personalities and try to figure out how to fit new personalities into the ones that I've already got, so you have to like that at some level. And you have to be a person who doesn't have good boundaries in your life [laughing], so it can't be, well, "this is the work and it stops now," and, "this is when *this* starts over here," it has to be, well, "this is my life, there's always these people swarming around, and this is what you do." And, so, that's that.

Earthwatch, it helps because of the meals. The whole communal living thing is going on, so you're eating dinner with each other. For the new butterfly survey stuff we're doing now, I don't think we have that and I think not a lot of people stay around for very many years – they just don't come back after a second year unless they're really into it. For the Appalachian Trail camera trapping thing we're doing, there's a welcoming party at the beginning of the year, and there's an end of the year party where you look over all the pictures from the team, and there's emails, you know, they send you the pictures and they ask what this is, and you reply to them. That kind of feedback is something that's important for them. So we're able to retain those folks a lot better than we are the folks – the butterfly thing you can register over the web, and we send you the protocols and you get going, and you send us the data at the end of the season, and, there's an awful lot of people we send the protocols to that we never hear from again. So, I think it doesn't work so well.

For the camera trapping project, the Appalachian Trail is really pretty consistent. If you stand on the Appalachian Trail in Georgia and you stand on the Appalachian Trail in Virginia or in Maine, you'd be hard pressed to tell any difference. It's just mature, deciduous forest. The Appalachian Trail itself legally is only 300 feet wide, it's just a little ribbon that goes from Georgia up to Maine. But, what goes on outside of that 300 feet is radically different. Sometimes you're going through a National Park, sometimes you're going through a National Forest with a lot of logging, sometimes you're going through suburbia. So your camera is always set up in the same habitat along the trail, but the matrix around that habitat is different. So, do you get bears and bobcats in one kind of matrix and raccoons and white tailed deer in another kind of matrix? Do you have some level of fragmentation where certain species just drop out? Or if bobcats are everywhere, then the Appalachian Trail is a corridor that these animals are moving along and blah blah blah. But, that's not really the case. For a lot of the species you only get them when there's a lot of forest around that Appalachian Trail. And where the Appalachian Trail goes through suburbia it's pretty much raccoons and skunks. And deer. You get deer everywhere on the trail. So that's an easy experiment to see, a clean concept.

There's another part of it now – we're talking about trail use itself – how much does trail use impact the mammals in that 300 foot wide corridor? So, compare sections of the trail that get heavy trail use with those getting low trail use. And we can find both suburban and rural or wooded areas that have both conditions. You can go up in the Shenandoah Park and it can be a lot of woods but it has a lot of heavy trail use. Does that make a difference? The Appalachian Trail Conservancy would say, "I hope not, because we're encouraging people to get out there and hike, and use the trails, and get out in the woods," and if that has consequences for the mammals on the woods then that's not good. But, I don't know. There's a paper from California saying that parks with a lot of hiking activity have lower large mammal densities than parks with less hiking activity. So if that's the case in California it might be along the Appalachian Trail also. But I don't think so. I think here in the east we've already lost everything that cares about people. All we have left are things that like people. So I don't know that black bears care about people at all, deer certainly don't, raccoons usually don't.

We have two years of data from the camera traps but we haven't published yet[5]. You know, the graduate students are always saying, let's collect some more data, let's collect some more data. It's good in that we've got…. we accepted 285 locations the first year, and a little over 300 locations the second year. So that's 300 locations that the cameras sat for a month during the course of the summer. There's no way you could do that by yourself, or with one or two graduate students. So that's good. That's good.

We had also done a project in Clarke County, Virginia, which was a land use project. Actually, we were looking at white tailed deer. Part of that was we had landowners in the county fill in questionnaires about what they do on their land, and what kind of conservation easements they have on their land or not, do they hunt or not on their land. We got about 60% of the land in Clarke County covered with these interviews. We did a tremendous job, going to the state fairs, going to the County Fair, going to the Rotary Club, going to the Kiwanis Club, going to the 4H Clubs, just getting every landowner to fill in those forms. And when we were done with the deer study I was trying to think of some way to keep that group of landowners together, and some way that we could relate land use to biodiversity measures. We tried trip cameras for medium-sized mammals – we would essentially loan interested landowners the trip camera for a month, and they

[5] Now published: Erb, P. L., McShea, W. J., & Guralnick, R. P. (2012). Anthropogenic influences on macro-level mammal occupancy in the Appalachian trail corridor. *PloS one*, *7*(8), e42574.

would put it on their property and get pictures. We tried an invasive plant species survey, where we gave them a list of invasive plants and they were supposed to check off what was on their property and not on their property. But the butterfly thing seemed to resonate the most. The butterfly thing got the most people returning, and it's kept going.

The Blandy[6] was already doing a butterfly survey with their students. They have summer REU students, and those students had recruited some homeowners, so we knew it was possible. So we just kind of took over that butterfly survey and used it for our landowners and our system. People like butterflies, and it's amazingly easy to do. It's much easier than birds. *Much* easier than birds, because you can see them. And anyone's property has maybe only ten species of butterflies, if it's a really good property. A lot of them only have four or five species of butterflies, and you can pretty quick figure out what you've got and write it down. And so I'd say for five years now we've been having the people in Clarke County do it, and then the people in Rappahannock County wanted to do it, and the Master Naturalist Club here in Warren County wanted to do it, and Alan Peters who runs the Invertebrate House at the Zoo downtown, he said, this would be great for the FONZ[7] volunteers that use the Invertebrate House, and, and we could put out a display at the butterfly garden at the Zoo, so they have a training program there. So now we have, I don't know, there's twenty or thirty people doing it around DC and there's probably fifty to sixty people doing it out here.

The problems with it is that we tweak it every year to get the data to be more viable, and it doesn't work for you to just do it once or twice. What it is, is you're supposed to measure off an area in your backyard, and you go out and you sit there for an hour and write down all the butterflies that fly through that area in the course of an hour. But you have to do that five or six times, so that's a six-hour commitment, and not everybody's willing to give that. They do that first hour just fine, but to get through the whole six hours…. They're supposed to go several times in July, and several times in August, that's the best season for butterflies. And… that works. They can download the things online, and just do it by themselves, or we held two or three trainings out here and one training in DC, where we have slides of every butterfly and we talk about the different characteristics of butterflies, and then we send them off with their guidebooks and they do their thing. So, that's worked fine. Now, the follow up is that I have nobody to analyze that data. So I keep just, collecting it, thinking that someday I'm going to do something with this data. But it's kind of an open-ended thing. Every year I say, oh [sigh], am I really going to do the butterfly again this year? And then Alan Peters calls up and says, "oh, it's really important for our volunteers," and then the Master Naturalist Club calls up and says, "oh, our volunteers really love it, can't we keep it going?" And I say, "oh, ok," and organize everybody again.

[6] Blandy Experimental Farm, in nearby northern Virginia, part of the University of Virginia.
[7] Friends of the National Zoo

And most of this doesn't cost anything, it just costs time. Time is, you know… there's a lot of hours in the day. So we just… make the time. It doesn't cost anything. All we have to do is print off some of those guidebooks for folks, and… there's not much else to it. So that's a nice one, as far as costs go. Because the Appalachian Trail one, those cameras are expensive. The cameras break down, they get stolen, and they need film, they need batteries. And that's a much more expensive thing to run. So we've done that for two years now, and the Appalachian Trail Conservancy is saying, "we'll buy the batteries, we'll organize the parties for the volunteers, you just give the training and coordinate the data. And supply the cameras." The cameras we got on loan from the Park Service. So, we've been able to keep it relatively inexpensive. But all these things need real money to make them real projects, and we're just probably running around doing too many projects to be able to take one project and say, alright, let's make an effort to move this project to the next level where it's functioning in a good way.

Something like the Appalachian Trail project should have a coordinator, a paid coordinator. It should have somebody working with the data more than is working with the data. Right now there's two Master's students who are looking at the data and… I don't know, it's not as optimal as you'd like to have it. And, I originally wanted to do it for the entire Appalachian Trail. Right now I have it for a 400-mile segment, which is nice, but 400 miles ain't the whole Trail. So, I'd love to be able to move it up to the whole Trail, but that kind of money just isn't available. And I'd like to do more for the volunteers. They want to interact more than they are, and they'd like to interact through a website. And we just don't have the capacity to make that website more interactive than it is right now. Say they got a bobcat picture – they'd love to talk to other people about that bobcat picture. They just surveyed in the lower Shenandoah Park… who else has surveyed down in that area? What stories do they have? You know, that kind of thing, and we're not able to do that. All we can do now is say, post the folder of your pictures up to this site. It's folder 473, 424, and you don't know where those pictures are from, or who posted them up there, or what. You can look at all the pictures and go, "wow, that's a great picture, that's a great picture …" but you don't have any capacity to communicate with each other. So, I'd like to add things like that. Right now, everybody but one person who volunteered the first year re-volunteered the second year. And that's seven months, seven months of going out every two weeks and moving the camera, checking on the camera. They love it.

We have fifty teams of people. It's rare that a team is one person. Usually a team is three or four people, because two of them will go out one trip and two of them will go out another trip, or whatever. So, that's good. That's the best example I have so far of all the work they do, and for how little effort we put in to get that work out of them. It's an amazing piece of work. But… it would be a good thing for the Park Service to pick that up, or the Appalachian Trail Conservancy to pick that up and just run with that. I'm supposed to be a researcher, I'm not supposed to be running a ten year volunteer program. I'm supposed to be doing a research project and moving on to something else. So, as a monitoring program, it would work great. But I'm not in the business of coordinating monitoring programs for somebody.

For research, I have to think about, if I do something for three years will I have a result at the end of those three years that I can publish? And three years is just an average thing, maybe it's five years. But I have to have a hypothesis and I've got things set up so that I'm testing one condition vs. another, and my sample size is such so that at the end of this time I will have enough data to publish this thing. And that's not the same as saying the world is changing, we don't know how these changes are going to effect the system, and so we're going to monitor the system over time and be alerted to significant change or new things coming down the pike. And not targeting too specific parts of the habitat, or two conditions, or not trying to load your samples into specific grasslands or specific forests. And I'm a researcher who has to have publications, so I can't afford to say, "let's just see what happens, let's see what changes over time, let's keep track of things." I'd like to do that, but I can't do that. I have to say, "I have a mission." Now with the Earthwatch, where we did that over nine years, what I did was I just kept adapting my research, in that I said, "well, here's the first question that I'm going to ask," and then as I'm winding down that question I say, "well, we can answer this second question – can I maintain the same protocols or do I have to tweak these protocols a little bit in order to get this second questions?" But, I have to be willing to say, "my primary mission here is not monitoring, my primary mission here is to answer this hypothesis, and if I have to change a protocol, I have to change the protocol." Whereas if you're in some monitoring program, you're not changing the protocol. You got what you got. Assuming you're not doing some kind of density estimate that can just, you know, sometimes you're doing something that the estimate can be gotten different ways, and you're just changing the way that you're getting the estimate. But if you're doing an index that is very sensitive to the protocol, then you've gotta think twice about changing that protocol.

I have scientific questions, but since I'm not actually doing anything with the data I don't know whether those will be the ones that are done at the end. For the butterflies it's easy to say that I have people collecting butterfly data across a large range of land uses, and I want to see if land use has a consequences for the biodiversity on that land. Does it make a difference, if you have forest and this guy has forest, and your forest is a conservation easement, but his forest is not in conservation easement, does that make any different at all? You live in a part of the county that has very small pieces of property, and *you* live on quarter acre lots, and *you* live on ten-acre lots. It's the same percentage forest/field, does it make a difference, or does it not make a difference? And that kind of stuff, to have a broad range of that stuff, I can do it. But I haven't done it. The butterfly biodiversity has enough variability, some houses are getting only two or three species of butterflies, and some are getting twelve, thirteen. I think sixteen is the most that any place had. So you do have some really diverse sites, and some really depauperate sites. The butterfly stuff is still sitting on my desk. Maybe that's because there's nobody tied to the butterfly data, whereas the Appalachian Trail data, which actually started after the butterfly stuff, I've already seen drafts of a paper there, and that'll be done pretty soon. There's a graduate student whose life depends on it, so they have more incentive to move it along! Whereas the butterflies, there's no graduate student attached to it, so it's just, if I ever get a free day I'll look at that for sure. That never happens.

People have been doing butterflies in their backyards for about five or six years now. I'm trying to blend that project in a new warm season grass restoration project we started, where we're trying to talk landowners into doing grassland restorations on their land. In return we would do biological surveys to give them snapshots of how their land is doing. We do a plant survey, and a bird survey, and a pollinator survey on their land before they do the restoration, and then supposedly we're coming back in a couple years, and a couple years after that. And each one of those three surveys has their own survey group. So the plant people are organized into a group, and the pollinator people are organized into a group, and the bird people are organized into a group. They're all citizen scientists – the plant people all come from the Virginia Native Plant Society, or most of them do, and the birders are from the birding clubs. The pollinators are people who have pretty much self-identified themselves and gone through some sort of training. That whole thing, we just went through one field season. I just had a meeting with the pollinator group about what are we going to refine for the second season, and how are we going to do things the second season. So that's all new, and is something where I have a volunteer coordinator, someone whose job it is just to keep track of all these three surveys that are going on, and who's collecting what data and where is it going and who's good and who's not good.

So, to get publications from this, I need mechanisms to either check on the data, or have a confidence level with the data. I need that volunteer coordinator, I need some certain number of points being checked by somebody else, something like that that allows me to be confident in my own mind, and be confident in when I put it out for review that the reviewers be confident that things were checked, that things are ok.

The way I used volunteers before is the volunteers were working directly with me, and I would go someplace and the volunteers would go with, and we would all work together on these things. And its becoming much more of me doing things – I'm spending far more time at my computer doing things and the volunteers are either out there by themselves or they're out there with somebody else. So I'm a step removed from everything now. That's what's changed over time. And I just have to hear the tales of what happened and try to translate that into what I know. I think once I got that step removed, I've come to the realization that someone has to be watching the volunteers, there has to be a volunteer coordinator, a supervisor of the folks, who is doing the checking. I'm spending more of my budget on a volunteer coordinator, as a way to check on the quality of stuff that's coming in. I think I went through some transition of, "I can have a training session, I can tell everybody what they need to know, I can let them go for the season and I can believe the data at the end of the season." And now I'm much more, "somebody has to be checking in on them all the time, and somebody has to be, going out with different people," and if it's not going to be me, somebody has to be doing that. That is where I currently am.

And it's the same with the Earthwatch volunteers, or any of these volunteers. If the trip camera ones were having problems with…. You know, I say everybody signs up to do that again, but there's some of those people we wish would not sign up to do it again because as far as we can tell they have yet to collect any effective data. We give them the camera, they set out the camera, we reject their data and we say, "do it this way next time," and they say, "oh great, ok, I'll do it differently," and then they don't do it differently next time, they just…. We need a better mechanism for throwing those people out. Right now we don't have any, we *so* want volunteers so we don't say, "there's going to be a tryout," or something. We don't know, what is the mechanism for getting rid of those folks, they don't…. Earthwatch, I have more control over that. With the trip camera project, they're kind of on their own, so, I wish… I don't know how I can do it. But, all we do is reject their data. We can see from the pictures that the data's not good, that it can't be used. So, we just reject it. And it doesn't seem to bother some of them, they just keep collecting data, even though it isn't being used, they just, they just like the process of being part of the team, and they like the process of going out there and setting up the camera, and it doesn't seem to bother them that we always reject their data [laughing], they don't seem to get it. I don't understand those folks. They know I'm not using their data, it's communicated to them. It could be it's communicated to them in too subtle a way, because at points during the year we say, "this is the data that we've accepted so far." We don't say, "here's the points we rejected." So maybe they don't realize, maybe they really don't realize that when they look down that list their name and their points are not there. [laughing]

And I don't know how much of a problem I'm going to have to publish these data. Well, all the Earthwatch stuff was done much more with me directly there. So the volunteers were much more in an assisting position, rather than in a collecting position. Like I did not send any Earthwatch person off to get a piece of data and bring it back to me. Now I am much more into this, "I am giving you the equipment, I'm giving you training, I'm sending you someplace, and you're coming back with some data." Looking at the quality of the stuff we got for the Appalachian Trail project, I think we're going to be ok. The butterfly data, and the warm season grass stuff, I'm still not convinced that we're ok yet.

I am supposedly getting some research product out of everything that goes on. But… that's not true. In reality, most projects don't, a lot of projects don't, they never reach the research *product* stage, where there's a publication at the end. And, and for me at least, I've just come to the realization that that's ok. That's ok, that people gain along the way. There are interns who get experience, that gets them into graduate school, there's the volunteers themselves who become more connect… see that science is not some black box thing, that it's something they can do. They know a scientist now, and he's their best buddy, and they can send pictures to him any time they want, and, and so they have their things that they're gaining, and I… I learn things that are never going to end up in a publication, like butterflies. I'll tell you, when I went into the butterfly project, I didn't know a butterfly from a hole in the wall. I knew a monarch butterfly, I knew the other butterflies that weren't monarchs. But now, I can actually name a few butterflies! And I can sit around and discuss with them, you know, whether that was a varied fritillary, or a meadow fritillary, or whatever, and hey, that's a little knowledge for me. And it may never turn into a publication, but, it was a nice thing to do. We're trying to recruit a bunch of volunteers now to do native plant restorations here at CRC, and so I've gotten all into this invasive plant stuff, and warm season grasses, and I don't think any of that is ever going to turn into a publication. We're trying to set up some experimental designs but I bet you it's all just going to be fun and games. That's ok. As long as I can be productive in other projects that will have the science output that will keep the bosses off my back, then, I can afford to fool around on some of these projects that have these other benefits to them.

If I think about the warm season grass restoration thing, the federal government and the state government own almost no grasslands. We own a bunch of forest. And almost all the grasslands sit in the possession of private landowners. It's all these cattle ranches and hayfields, and hobby farms that are all throughout this area. That's where all the grasslands are. And if you want to do some kind of grassland restoration, you can't go to Shenandoah Park. They have Big Meadows, that's all they've got. 99% of the Park is forest. Same with all the parks around here. So, if you really want to do conservation on that ecosystem you gotta be working with private landowners. And they're antsy about government people, and official workers and they're much more, they seem to be much more receptive to citizens, to the general public, to the birding club. They like that, they seem to like that better than the government's going to send a team of people onto your land to see what you've got. So it seems to work best.

Right now, the only landowners we're able to talk into this thing are rich landowners who are not trying to squeeze every dime out of their land. You know if you're trying to, if all your income is coming off that land then you're very reluctant about doing anything that might you know, say we say it takes two years to establish a warm season grass site. You know, they're not going to take a piece of land out of rotation for two years. So only people who, yes it's fine if they make money, but its' not, you know, it's not their primary mission, they like having a lot of land, they like seeing animals and having diversity, they go into this thing. So, most of them have, an affinity to what we're doing and, and are really interested in it, but the original idea was that you would, we would train you, you would do the surveys on your own land, but these people don't have that time, they are off for two weeks in Florida, and then their kids are coming in for the weekend, and then they're, they've got this place they've got to go to then, and so, what we've gone down to is, we'll tell you when we're doing them, and if you can be involved, great. And I'd say most of them never hook up with the surveyors. They all say they're going to, they all say that's great, but in the end they don't. We give them lists of what's on their property and they like that. They like the lists. So they're all receptive to it, they just are busy people. They like me as an individual [laughs]. I know at the end, I know that what they want is for me to come walk on their property and name everything as I walk by it, and, but I can't, I just can't do that. It's better for me if I can find naturalists who are, you know, if they're going to do the birding survey there, the landowner wants to come along with them, fine. That's a better angle for me.

When I'm selling the warm season grasses project, I'm selling it that, for grassland birds in particular, the birds need scales beyond a single landowner's property. The federal government and the state governments have a lot of trouble pushing people in certain directions. But it seems like these landowner cooperatives do not have nearly the same resistance to change – we have a lot of landowners talking to other landowners, saying "hey, what are you doing over there? Ooh, I want to do the same thing." Whereas if I came to them and said "I want you to save these grassland birds, they would say "well, you know, give me a tax break for that." So, it works, it works. It works. And the other issue in this area is that the original focus is grassland birds, and the federal government and the state government actually own very little grassland. They own a lot of forest. The only people that own grassland are the private landowners. So they're an essential part of the solution. And I think the state realizes that, the state has quail plan things where they're, they can give money to landowners who adopt certain management practices that are conducive to having quail. But most of these landowners don't know about it, or are not interested in taking direction from the state. But when they find out their neighbor just did something, then they ask their neighbor "how did you pay for it?" and they say "oh, this state guy gave me this money." Then they're interested in it. Whereas if the state guy went to them directly, they wouldn't be so interested in it. So, it has been helpful. It's a different angle than the – it's almost like we have two things going on, we have the landowners, and what the landowners are doing on their land, and then we have the surveys involving the Citizen Scientists, and they both have their own reasons and logistics.

The warm season grass thing is eating up my life. It is growing. I mean, so we did 12 sites the first year and we've done 25 sites this second year, and we have a lot of sites on a waiting list, we just don't have enough volunteers to do the surveys. And that's the bottle-neck right now, getting trained people who have a realistic – one, the training, and then two, a realistic sense of what the work is involved. Because both years so far, we get a lot of people who take the training, and start doing the surveys, and then find out "hey, this is boring", or "hey, it's hot during the summer". And then they stop. Or, like one of the bottle-necks is pollinators, identifying all these native bees. So, USDA has a one-week training in the bee identification. And you send them to this place, and there's room and board and a fee for the course, and it's, you know more than a thousand bucks. And we've sent four people now to take that course under the promises that after the course they will help with the pollinator surveys. And all four of them have fallen through since they've taken the course. Got pregnant, moved away, eyesight is not good enough, health is failing. So – that's a bottle-neck. So right now, from the second year, we have finished – we did bird surveys, plant surveys, and these pollinator surveys. And the birds and the plants are done, and the data's out there, and the pollinator stuff is maybe a third done. Just because everything was collected just fine eventually, but the identifications are just taking forever, and I'm worried that when I go to do the training, or recruiting people for this coming year, and they don't see the results of last year's work, then that will discourage them. So that's our issue right now. That's – when it comes to the citizen science, that's the biggest issue.

We did get an NSF grant to expand the camera trapping, and we haven't gotten started on it yet, but we are getting a post-doc for the citizen science thing. But that would be to select ten different parks, and have those parks all be surveyed by different volunteer teams, and the teams be – naturalist clubs or boy scout troops, or groups adopting these parks. And I still think having groups adopt it as opposed to individuals adopt it is a better way to go.

I find volunteers by hook or by crook. Now we have an outreach coordinator here, and she has a network of clubs and organizations and she usually works through those clubs and organizations. We'll generate a posting for some need, and she'll send it out to her clubs and organizations. Sometimes it's people coming in through the website and finding us, but that's maybe 10% of the time. And, a lot of these postings we're finding the same people who worked on the previous project, or the project before that. They're just interested in something new. So it's definitely a limited pool of people.

The camera trapping one, it helps that the Appalachian Trail Conservancy is, takes over a lot of the volunteer management, because they want to do this as a way to bond the volunteers to the Appalachian Trail Conservancy. They don't want the volunteers bonding to me. I probably don't want the volunteers bonding to me. They want them to bond to that group because that group has goals and aims. They're trying to increase their membership and their trying to get more people involved and this is a way for them to, for them, they have, they've always had trail maintenance, and they just can only recruit so many people to take a chainsaw and cut trees off the Appalachian Trail. Or take a shovel up there and carve out some cliffs. How much recruiting can you do that with? But they can have little research projects, go photograph these mammals, they get a whole nother group of people coming into the club. And they're happy for it. And I'm happy for them that they take some of that off of me. So, that's good.

I think it ebbs and flows, that you *are* a scientist, you *are* supposed to be producing publications, you *are* supposed to be bringing in grants, and a lot of these things don't end up heading toward the big grants and you should drop them and do the things that have the products. But there is, there is, especially within the Smithsonian, the whole, you know, "increase and *diffuse* knowledge to men." We have to diffuse this knowledge out there. And especially within the federal government, I am one scientist, I can only stand one place in any time, I cannot do everything that has to be done. So, if I can recruit these people into the system, it's a multiplier effect that I can, I can be surveying the Appalachian Trail and collecting butterflies at the same time [laugh]. And, you know, the, I am not, if I, if the federal government would turn around tomorrow and say, well here's technicians for you, I'd say, "ok, well now there's a lot I can do." But it's not going to happen, it's not going to happen any time soon. So if, the increasing, diffusing part is going to have to involve volunteers. And I think there's an awareness of that. It still doesn't, there's nowhere on your annual evaluation that that clicks off, you know you have to click off these boxes, and, gave, published so many papers, brought in so much money and gave so many invited presentations, and, there's nowhere for clicking off, "47 volunteers on this projects, 7 interns at this time," but, there you go.

I think the citizen scientists have a big interest in this, and they love, they like to be a part of it, and they like to learn about science and do science, so, it ends up being an education component of what I'm doing. But I don't approach it that way. I know there's some benefit to the volunteers, but it's not my primary aim. I'm doing it because there's no other way I can get this work done without them.

They are, they're increasing their personal knowledge base for the most part. They want to learn something new every day. As long as there's something new they're engaged in it. There's only a few of them that are into the, let's do the same thing we did yesterday, because Dr. McShea wants it. They, they need something new coming in. And … that's our problems with retaining people. I don't know what else I can say about that. They'll, you know, it's hard to put all the volunteers in one lump. Because there certainly are retired people, there are, there are young people, there are people who used to be in the field and aren't any more and want to just do something. But I think most of them are motivated by the knowledge rather than the… maybe if we had people picking up garbage they would be more into saving the earth or something like that. But I don't really get those kind of people. I get people for, "I want to learn all the plants. I want to learn the trees. I want to learn how to do this or learn how to do that."

And what do I learn? I guess there are two learnings. One learning is, the actual volunteers themselves, that I need volunteers to come back year after year. A volunteer who works on a project for one season is only going to get so good. And, they really need that long-term commitment to really get to love all that, that we've gotten as much variability out of them, removed as much as we can. But the second part is just us, the second variability is us – the protocols, and the training, and refining that so that we know where the error pathways are now, and we can address those error pathways when someone gets started. So they don't go down the wrong path, and they realize where they're going to make their mistakes. We realize where they're going to make their mistakes and we head them off at the pass. And, I think both those things happen over time.

For me, I get new knowledge, I get new publications. I get new questions that cause new research projects, which get new knowledge and new publications. So that just goes on and on for me. From the volunteers' point of view, they get a glimpse of the life of a scientist, and they gain some natural history information that is rewarding to them. The other benefits are that interns get some experience, the volunteers have a better understanding of nature and a better understanding of science, and a better understanding of scientists, and that I personally learn new things. Everything I learn doesn't have to end up in a publication for the scientific community. I'm allowed to learn things just for the hell of it, because sometimes it comes in handy. Sometimes a little thing that you learn in one project ends up being helpful in another project, like how to manage people. The big problem with all of that is money, money, money, money, money, money, money. There's not enough money to do things as well as they should be done. And that's, that's the biggest problem.

And it's always a trade-off between – instead of you spending all your time in the data collection, you're spending all your time in the logistics organization. And which is a better use of your time, I don't know. In this case, I'll tell you in this case, I know nothing about pollinators. Well, I know nothing exactly about pollinators. And I know very little about native plants. I could not do the surveys that I am sending people out to do. So, that's amazing to me. But there are people out there that have these skills, and it's almost like they don't know what to do with them. And I'm saying, "ok, you have this skill? I can find a job for you. I would love to have somebody go here and do things using this protocol." And people say, "ok, that sounds like a good – I'm glad I can use my skill some way." They're all volunteers. But they want – you know they're all in their forties and their fifties, the vast majority of them, and they've spent a lifetime accumulating this plant knowledge, and they want to do something with it. And I can say "well, I have a good protocol that I need done," and a lot of people are saying "ok, let me do it."

I used to spend a lot of time explaining how things worked in this wood plot, or how things worked in this field, and I rarely do that anymore. I'm more talking across a much broader scale, how the distribution of animals across that scale is changing or how the distribution of people and habitat and animals is changing across the scale and how they might be interrelated to one another. And the problems are that I'm dealing with a lot more noise than I was at the smaller scale, and that means I need a much bigger sample set to account for woodlots that are on the west side of the hill, versus the woodlots that are on the light side of the hill, and woodlots that are near towns and woodlots that are not near towns, and that all, all that variability is something that you spent most of my masters and my PhD trying to eliminate and now I'm spending most of my time trying to incorporate, in that that variability is, is life – there's no practical experience you can give to managers if you have to control all the variables before you can give them that advice. So I need to be able to say across a broad landscape this is what's happening. And what you lose is that, at this one specific site, things may be slightly different. And there are reasons why that might be different, we could go into that, but I'm trying to give a broader view to things.

Part of it is that I'm just not looking at, me personally, I'm not looking at the fine-scaled things anymore. I'm not looking at things that make a one percent or two percent difference in some animal distribution, because I have so much variability in my system now, due to either the environment or the collectors that I can only look at big things. I can only look at things that, despite the variability I can still piece those things out. And I think I can, I think every year we refine the volunteers, we refine their protocols, and we discover new avenues of variability that we can get rid of. And, and we do that. And they get better and better every year. So, to some extent it's always an adaptive management things, where you're, you're starting out with, ok, I'll take this, I'll accept this amount… well first, before you start anything you think things are going to be perfect. And then when you actually collect the first year's data, you see, oh, this guy was setting out cameras totally different than this person who was not doing it the same as that person, and everything's worse than you thought it was. But then you find you can, people do learn, and people do get better, and if you can give them the right kind of feedback you can, you can do some kind of adaptive management and end up with a system that gives you not a perfect world, but good enough.

For my masters', I had a one hectare plot. You know, and I knew everything about the mice, and the trees in side that one hectare plot. And so much science now is thousand square kilometers, two thousand square kilometers, doing the Appalachian Trail from Maine to Georgia, that's not the kind of thing that, that's not the kind of science that used to be done. If we're going to do science at that stage, it just takes hundreds of people, and those aren't going to be employees, there's no, there's no way those are going to be employees. It has to be volunteers and citizen scientists. So if we're really moving toward some continental scale monitoring, or landscape scale monitoring, or, it's going to be groups of people all organized with similar ideas. And the web makes that all possible. That everybody can get the same protocols, and everybody can load up their data, and, it can all come to a central place, there's no way that, you know, when I started there was no way that could happen.

A couple weeks ago I had a meeting with the National Wildlife Federation wanting to do something national with both the camera trapping and the warm season grass project, and how could these programs ramp up to a national stage. And I didn't think they could. So right now, what we're doing there is we're going to bring on one person, they're going pay for a person to come onto the Virginia Working Landscapes, the warm season grass thing, and just focus on what parts of this can ramp up. What do we need, what are the parts of this that we need to change in order for it to ramp up, because right now it's done – everybody comes here and gets their training, we check in on people, we can go to someone's house and get a pizza-box full of bees, right now there's a lot of that happening. And if you went to, there are people in Indiana and there's people in Ohio, then how am I training them, and how is communication happening? I don't think that stuff is gonna work. But, if they want to look into that, fine. And that's what they're gonna do.

I think there'll be more citizen science things and not less citizen science things in the future because, just demand, just because one of the manpower shortage, and two… So, I think it's the way of the future. It just needs better ways to fund that effort, because the volunteers take money just the way other things do. And coordinate that effort. And then there's the data quality insurance part of the whole thing. If those can only be dealt with. Certainly there are organizations that are doing pretty good. Many projects should just be, you know, well, I'm willing to give something a try, let's get some pilot data and see how it goes, and hopefully we can parlay that into a grant to support something. A lot of times it doesn't happen. It takes somebody dedicated to finding the money for that one project, or the way you craft it is not the way the foundations you're going to want it to be crafted. And you say, well, I can either change the way they want and try them again, or I can just say screw them, I'm going to keep doing it the way I'm doing it. And, there's no right answer to that. It would be great if there were some ability to tap into the, you know, just as there are people willing to volunteer their time, there's people willing to volunteer their money for the people who are volunteering their time. We just don't have a way yet to access that money, the that Barack Obama can raise so much over the web, or through individual contact. And that kind of money raising is not – I'm not capable of doing that and none of us are capable of doing that. WE could use that money just as much as you need it for a presidential campaign, we could all use that money just as much. I mean, creating these volunteer networks, somehow those volunteer networks should be able to, a similar type network should be able to generate cash to keep the volunteer networks going[8]. But, they don't [laugh].

I think part of why I keep doing all this is a problem in my brain, that I just can't leave well enough alone! [laughing] The other problem is that, is that a whole lot of things sound good on paper, and until you actually start collecting the data you don't know if

[8] This interview was conducted before crowd funding became a known phenomenon.

it's going to work out or not, and I tend to start a bunch of projects and some of them work and some of them don't work. And, I can't know until things are going, you know. It could be in another year I decide this warm season grass thing is not really worth the effort involved. But I had to start it and go through process in order to see. I'm not good at selecting before actually doing. Being more selective before I actually get started. So, it's, it's advantageous to me to start three volunteer projects and have only one of them actually make itself all the way through to the end. I don't know if that's frustrating for the volunteers, or if the volunteers even are aware that some of these things are not moving through to the end. Because their end is different than my end. Most of them don't seem to care less if, couldn't care less if I make a publication or not.

And, it's stubbornness, stubbornness. I think what is attractive to me always about the citizen science stuff is being able to work at a much bigger scale than I usually would be able to. And to have 25 properties being sampled at the same time. One individual or me with two interns couldn't do that. And then there is the center – you know there's my science end of it, but now the center itself is very excited about this project, because it is their main – it is a major way for them to get in with these landowners. They – it's almost like by doing the warm season grass things, these landowners now owe us a favor, or have a connection with us. And then that connection is used for "oh, do you want to come to a donor party", "oh do you want to be part of our friends group", "oh do you want to hear the exciting things that are going on at SCBI". And all that is – gives them a way to get into people that they wouldn't normally get into. And to establish a local reputation that the center did not have before. So I get a lot of pressure from the administration end of things now to include this landowner, include that landowner, or this person wants to be one of the survey sites, and they may not be exactly perfect but they're the kind of person we want to be talking to. And I'm ok with that. Because it shows the center that there's a value in this kind of stuff. So, it's a little price to pay. But that scale, that scale is the main thing. And it's not any different than at Earthwatch, it was the amount of data that was being collected at one time at one place. Now it's just the geographic range over which the data is being collected.

There's two connections between citizen science and conservation. The one connection is me personally, as a scientist being able to get more data from more places if I can just tailor the protocols and the requirements to the level of the expertise I have, that is an advantage to me. I think there's a real advantage to the citizen scientists and to the people whose land they're going on to engage and involve them in the process, that everybody takes a lot more ownership when they've just spent twenty hours counting plants. Then it becomes a little more important to them than if they just went to a lecture for an hour. And that involvement – and the landowners, the landowners, you know, here are these volunteers coming on their land doing this stuff, and they see them out there all day, and they say "what are you doing, and why are you doing it?" And that seems to have a lot more power to them than here are four state employees coming on my land. So, those are the two angles that I think make citizen science worth it.

Wallace "J." Nichols
California Academy of Sciences

Love is not off limits

As a high school student, I received an Earthwatch scholarship to take part in a sea turtle research expedition. While my experience was in the Yucatan, and J.'s research with sea turtles is on the western coast of Mexico, I still could envision very clearly many of the experiences he describes having with Earthwatch volunteers. My own experience was a transformative ten days. J. has been working in Baja Mexico for close to 20 years. With Earthwatch as a starting point, J. has now become a prominent voice for ocean conservation. His enthusiasm for this work extends to topics that are sometimes seen as in conflict with science, such as love, and fun, and building relationships. J. has received particular media attention for his work with turtle hunters (often referred to as poachers). He is candid about his process of developing relationships and his position as an outsider, but scholars of participation and power would nonetheless remind us, as readers of this story, to consider that the turtle hunters and other members of the communities in Baja might offer different narratives about these collaborations.

My name is J. Nichols, and I'm a marine conservation biologist. My work is focused generally on sea turtle biology research and conservation, but increasingly lately broadening to include a wide range of marine conservation issues, and community-based work involving the ocean, with sea turtles as the window into some of those things. I live in California – my academic base is the California Academy of Sciences, in San Francisco. And I work with a number of non-profit organizations – founded a few of them – and advisory boards, and board of directors, and affiliations with… I don't know how many these days, but a lot of organizations. And that's kind of a different approach to things. I found that there wasn't one organization or research unit that encompassed all the things I'm interested in, not really in a Pollyanna-ish way, but a problem-solving kind of way. And so I decided to shed the concept of having to work for one entity, and to rethink a career, in terms of working with lots of different organizations and agencies and academic departments – to create a career, like a very collaborative, and inter-institutional approach. That can include for-profits as well as non-profits, and fishing co-ops, and individuals, and so it's kind of an experiment in career-making as well I guess.

If you really wanted to drill down into the psychology of why one might be…. I was thinking about this before now, thinking about, where does the openness to participatory research science begin, when you haven't done it before? Or at least, where does the openness to that idea come from? I don't know. But, if I think about my upbringing, I was adopted and grew up in a family with an adopted brother and three foster sisters, and a revolving door of exchange students, so my upbringing was like participatory science in a way. I was immersed in it from birth in a way. The people who raised me were not my biological parents, and I was surrounded by my non-biological brothers and sisters, and so I had this childhood of kind of wondering. I mean I'd look at people on the street and say, "oh I wonder if that's my mother/father/sister/brother." That may have something to do with it.

And then I became very curious about things like genetics. Which led me to science. And it's been on one path of human genetics, and human behavior, as well as just a passion for the natural world. And then I discovered my biological family and turns out I'm one of seven kids, and then discovered their families, and so I have a family "hedge." So for starters I come from this family that's very, very huge, I'm one of eleven brothers and sisters if you count my foster sisters and my adopted brother, and my biological siblings, with two mothers and two fathers, and a lot of love and a lot of, just a clan and a half. And then two kids of my own. So some of that I think is relevant to enjoying big, messy approaches to solving problems, or at least not being afraid of inviting anybody who doesn't have a place to have Thanksgiving dinner, you know? Having them all over, and throwing a party like that, and maybe even preferring it.

So the idea of inviting a group of strangers who are new to your work, and inviting them to help, is somewhat natural, maybe less repulsive to me compared to how other scientists may view it. I can't imagine another way of doing things. There's a sort of a basic understanding of how the world really works, and it is messy. And it is complex. And the participatory aspect makes all kinds of sense. So the idea of starting out with Earthwatch[1], I viewed it mostly as an up side, not a down side. And particularly because the experts in the world had decided that the Black turtle, which is one of the local species of this research, they decided it was basically too late, and so therefore there wasn't funding available. So my advisors basically said, "don't bother, and we strongly recommend that you not pursue this project." That's always awesome to have that kind of support. And so there weren't foundations lining up, and there was really not any government money, so Earthwatch seemed like a possibility. I applied for their support, which comes with half a dozen to a dozen helpers every two weeks – which sounded great, sounded like fun to me – to share the ride and the experience with people who were interested in sharing it, and in the meantime funding the work. So one aspect of it is the labor side of it, the work, and the other part is funding. And then the social side of it, just having people along just adds to the richness of the experience. So Earthwatch showed up – or we invited them and they said yes – and that was a great relationship for over a decade. I think it was '94 or '95 we got the first Earthwatch grant. That relationship continued for a good ten years.

[1] Earthwatch.org, a private organization offering field research expeditions for paying volunteers and grant funding to the scientists who host them.

I studied Biology and Spanish as an undergrad, and then I went to Duke and studied Economics, and then realized that I missed the natural science, so went back and did a PhD in Ecology. And as a young PhD student I started a non-profit, so that I had a place to run grants if we were lucky enough to get some.

I was a beginning doctoral student at University of Arizona, in Ecology and Evolutionary Biology, and Wildlife – sort of split between the two departments because the EEB department was slowly phasing out all the "-ologies" and the Wildlife department was picking them up. Ecology and Evolutionary Biology was becoming more theoretical, so the field-based natural histories and conservation-oriented stuff was de-emphasized, and the Wildlife unit was picking up a lot of that, so I was sort of between those two departments.

Another grad student and I worked together a lot – Jeff Seminoff, who's at the National Marine Fisheries Service now. And I say "we" a lot instead of "I", because it's always we, it's fairly rare that it's you alone doing anything, so it's just more comfortable that way. And I guess I'm just used to saying we instead of I, maybe to a fault sometimes.

I think we were both somewhat familiar with Earthwatch. I may have brought a catalog in and said, "hey, this is an option," because I was familiar with the catalog, their cool portrayal of all their different projects. I'd seen it around, I'd seen it on the news stands and admired that stuff, and then you're kind of like, "ok, everybody's saying it's too late, funders are not lining up, I need to go…." It was slightly pre-internet in terms of really being able to go out and do a big massive search for foundations, so you look through the grants foundations guide, and Earthwatch was on the list. That combination of them being on the list of funders in the world, and being familiar with what they do and their effective marketing through their magazine/catalog.

And in terms of the committee…. There was a pretty pivotal committee meeting where they basically said, "we're officially and strongly recommending against your project, if you want to waste your own time, feel free." And you know my answer was, "yes, yes please, I will gladly waste my own time," and I decided to pursue the project. Everyone said there were too few turtles, it's too late, go to Costa Rica if you want to study turtles. If you want to ask an important ecological or evolutionary question, you need some animals. If you don't have animals, then you can't get your degree. This was a pretty experienced group of people giving their best advice to a couple of young scientists, and I think they had all been through something of the sort before, in terms of students or colleagues trying to study animals that were disappearing, and so they were sharing their advice and understandably suggesting that this might not be the best choice of thesis subject. And then we didn't take their advice. So from the advisor role, they advised against it, so anything that happened next was pretty much out of their control.

They thought the whole thing was a waste of time, I think I would say. At first. So, Earthwatch was the least of anyone's concerns.

But, it just felt like there was something in the work, you know, it was just – I would like to say an educated opinion, but we were very green, so it wasn't necessarily an educated opinion. It was fully familiar with the literature. And I'd say an educated enough opinion to say, "we need to take a shot at this, and if you're right that it really is too late and we're wasting our time, we will have wasted our time, but hopefully not yours." At least that was my thinking, Jeff may have a different take on it, "I felt like J. was up for it so I was up for it." I don't know if that… we had each other, I guess. And we had a hunch, a gut feeling based on everything we knew, that it was worth… that this was a group of animals worth giving a shot. And that's what we did. We spent a little bit of time in Baja, and convinced a fisherman to help us out, even though we had no funds and no permits, and we did catch a turtle with him, and that was enough to convince ourselves that there was at least one turtle left and you could catch it, and then come back and make a case for a pilot project.

It was really pretty rough at first. There were turtles left – it wasn't like there was just one – but they were in the death throes of their decline, and the black market for their meat was still relentless. So it was a really unpopular project on a lot of different levels, not just in the committee meetings. It was politically very unpopular, because politicians are among the people who like to eat sea turtle, and suggesting that this illegal activity was driving turtles to extinction was not a popular topic. So we had resistance in every direction. And that's what we were going to spend our careers on. I have to say that if Earthwatch hadn't happened, if they'd said, "well you know you guys, this is a bad idea, and you're young, come back to us in five years," things may have gone… well, they certainly would have gone differently, and I don't know if, I don't know what that would have been. We may have cobbled something together in our own version of Earthwatch – which we occasionally did. Sometimes we'd put a flyer up on campus, and during Christmas breaks we'd attract a few undergrads who were willing to chip in gas money and food money. We'd take the whole Christmas break and go and do field work, and bring undergrad students along to help fund it in sort of an under-the-radar version of Earthwatch, no liability forms or anything like that, just an informal way of funding the work and getting people to work with us.

And we were really just asking basic questions. So, what's there? And the basic demographics, characterizing the population – how many males? How many females? Where are they, what are their growth rates, where do they come from? So, if we've got black turtles hanging out in Baja on the feeding grounds, where are their nesting beaches? Are they in Mexico, southern Mexico, Hawaii, Central America? Maybe the Isla Marías islands, which is a little island archipelago further south? What do the turtles eat, what are they doing on their feeding grounds, what's the home range? Those questions.

And we split our research questions up – I remember sitting down with Jeff and saying, "ok, you study local movements, and home range, and feeding ecology. I'll study long-distance movements, population genetics, sort of the bigger picture questions." And he was like, "yep, that sounds good," because that fit with some of the other ecological questions that he was interested in at the time regarding fish ecology. So we just assigned ourselves those tasks, which meant that he really hunkered down at one site and looked in incredible detail at what was going on in one bay, and then my interest was spread throughout the region, so I had to move around a lot between communities. I was collecting skin and muscle samples for mitochondrial DNA analysis and putting satellite transmitters on turtles throughout the region and tracking them, and of course building the social network, although we didn't call it a social network then, around the sea turtle issue. Those were basically everything. We needed to know a lot about what was going on – basic stuff, characterizing who-what-where-when – to know what we were dealing with. Sometimes it seems like the conservation agenda is used to justify research that may or may not be essential. In this case there was some really essential basic research that needed to be done, and the argument that it needed to be done was really solid, because very little was known. Didn't know where the black turtles were coming from, needed to know that in order to begin to try to help them.

And our advisors, as we built momentum, I guess you would say, and got a little bit of funding, they were more open to continuing to do the work. I mean, we got research permits, which at the time was a tricky and political process particularly with the black turtle, particularly a couple of young upstarts who were – I mean, we weren't defiant for the sake of being defiant, but some people may have interpreted it that way. And getting research permits was as big of a hurdle and time-consuming as getting funding and getting any of the other aspects of the work in order.

For Earthwatch, we would meet in San Diego, and then drive quite a long way together down to Baja, and then to the field site. That, as an initial experience, was exciting for some, and harrowing for others I imagine – this long, all-day drive in Baja. And then we get to the field site. The day-to-day work was focused on two main things, the mark-recapture work, which would be setting out nets, monitoring the nets, cleaning the nets – because a lot of algae would get in the nets and we couldn't have that. And then the exciting moments when turtles were caught in the nets, and then those turtles were tagged and measured and weighed and released. That was the main piece of the research work, the mark-recapture. Then, back on land there were holding tanks, where different turtles were being held for various reasons, including rehab. Those tanks needed to be drained, they weren't on any circulating filter system, it was just seawater pumped in and then drained every day, and the tanks cleaned, and refilled. So there was a routine related to keeping the tanks clean, keeping the turtles clean, feeding the turtles, emptying and filling the tanks. That was really kind of a fun thing to do because you got to hang out with the turtles in the shade – Baja is hot – and requires bodies and effort and hands-on contact with the sea turtles themselves. So those are the two main activities.

And then along the way different pieces of the project would happen, depending on – well, so sometimes we put satellite transmitters out, sometimes we put radio transmitters out. When we had radio transmitters out then there was radio telemetry work, so volunteers would go out and listen for turtles and get the bearing on the turtles – it's a triangulation – and record that. So turtle tracking was going on. That would be, not a constant, but certainly a lot of the volunteers had that experience, actually tracking sea turtles. Jeff's focus was on the local movements of the black turtles so he was more interested in what they were doing right there in the bay, and I was interested in more of the long-distance regional population biology, long-distance migration, so I was putting the satellite transmitters out and collecting skin samples for genetic analysis, and Jeff was focused on the radio transmitters and feeding, ecology. We would also – in the early days, we stopped doing it later – we would do something called gastric lavage, which is where you basically pump water into a turtle and everything that they've eaten recently comes out and you can tell what their food preferences are. I didn't much care for doing it, so as soon as we got to the point where we were pretty happy that we knew what turtles ate we discontinued that technique, just because of the invasiveness of it. So lots of basic research, sometimes less basic research, you know, the tracking stuff, and then regular, critical management, maintenance work. It was a hard-working project, there wasn't a lot of dilly-dallying going on. It was pretty much day and night work.

And there's a bit of a tour guide, cruise director aspect to it that is exhausting, frankly. Especially – as kind of an aside, I picked up Time magazine and this week its cover article is on introversion and the power of the introvert[2]. I took the quiz in there and I scored 20 out of 20, so I'm a 20 on the introvert scale. A lot of the article resonated, because I much prefer to be far, far away from people, alone, kind of quiet. I recognized a while ago that that's not going to be that helpful in terms of advancing the things I care about, so I needed to figure out a way to speak in public and I was very – I stuttered a lot, I was not a good public speaker in any way. Or not even public speaker, just not a good conversationalist, because I just couldn't do it. But I realized I needed to figure it out. So in that context, especially when you're the cruise director, that's an extrovert kind of job, and when it's 24/7 – I think part of the appeal of the project was that we – the volunteers and I guess you call us staff – we weren't segregated. We lived together in this very rustic camp on the ocean in Baja, and everybody worked together on the non-research stuff – food, cleaning up, the basic chores, dish duty. And so making all that stuff fun, as much as you can make dishwashing fun, was a piece of – I'd totally forgotten about it, but we would do the initial dish rinse – so most of the food was largely vegetarian, not strictly, but all for kinds of reasons including keeping perishables cold – the way we would do

[2] Walsh, B. 2012. The Upside of Being an Introvert (And Why Extroverts Are Overrated). Time. 6 Feb 2012.

dish duty routine was to take the dishes down to the edge of the ocean and do the first rinse off in the ocean. So the organics would just float off, and the fish would eat them, or they'd just degrade, after scraping the big chunks of stuff off for composting. And to make that fun, we had this – I don't know where they came from – they were these big bell-bottom jeans, and whoever was on dish duty got the privilege of putting them on. We called them the Baja Disco Dish Duty Pants. You got to wear the Baja Disco Dish Duty Pants when you were in charge of dish duty, and we had this rusty old beach chair, so you can put the beach chair in the ocean, in two feet of water, put on your disco pants, and sit there in the cool ocean rinsing dishes. We had floating buckets of dishes strapped to the chair on one side and the other one on the other side, so you were just completely silly. There are hundreds of people around the world with a picture of themselves in that chair, wearing the disco pants, doing what appears to be dishes in a beautiful setting. And that made dish duty fun, in fact, a photo op. And stuff like that – I haven't thought of the disco dish duty pants in a while. Making all those sort of things fun is part of it.

The feedback that we got directly from volunteers was always very positive, and then you wonder, "well, I wonder what they thought about it a year later, or a month later?" The feedback that we got *in*directly through Earthwatch was always very positive, including on my most recent trip. Even people at Earthwatch who have been hired more recently said they know about the project because of its reputation of producing really good science, being really fun and important for the volunteers, and apparently – I didn't know this until just this past week – the people who do the admin at Earthwatch thought we were really easy to work with, in the context of all of the projects. I always felt like we were running behind on our reporting and things but apparently we weren't, relative to everybody else. I guess we were conscientious grad students.

And then we had the realization that what we were doing there with the Earthwatch volunteers in that community needed to be happening times fifty, in fifty other communities in northwestern Mexico, so quickly you get into the scaling issue. When I talked to people who were entrepreneurs or advisors to entrepreneurs, they often talk about two things – execution, and scalability. We were now in the execution, but we weren't in the scale issue. So that was on my mind – how do we replicate, in some way, what's going on here in fifty other places? And that starts to become a little less practical as an Earthwatch project. And although we did take Earthwatch volunteers to other sites, and then created another Earthwatch project on the Pacific coast of Baja, you can't do fifty Earthwatch projects with sea turtles in northwestern Mexico. It just wouldn't work. So, I think the basis of the work even from day one was always to work with, to learn from, and to share with people in the community, and that there wasn't really an "aha" moment where we were like, "oh, wow, here's a strategy, work with the community." It was always just kind of like, that's what you do.

We had a policy early on – or at least I did in my head, my unofficial policy – that we'd never buy a boat, and we would always rely on fishermen with boats to provide all of what is related to moving around on the ocean. Whether that was a better is the rent or own debate, whether it's a better deal to rent or to own. We decided for a whole bunch of reasons that the benefits of renting would far outweigh those of owning. One was just the constant contact with the guys that owned and operated the boats. In our most isolated moment, whenever that would be, in terms of being foreign scientists working with international volunteers in a place like Baja, we could never become isolated, because too much of the team was from the community. Not that we were never oriented to becoming isolated, but even if somehow we weren't paying attention to the community aspects of what we were doing, it just couldn't happen. We were always reliant on the skills and knowledge and frankly the generosity of the people in the community, because we weren't paying tons of money for the service – it was adequate, but it wasn't the best deal in town by any means. So even when we were neck-deep in Earthwatch volunteer management, there was always a big part of the team who were folks from the community.

I would say from the beginning of doing field research I was like, "I don't have a boat, I need a boat… well, there are a lot of boats around here, a lot of boats." In every community there are a lot of boats. So, I don't need to buy a boat, I just need to work with people who have boats. And just even from the very practical-focused scientific agenda, "I need to collect DNA, I need to put some transmitters on some turtles." Even if those were the only tasks, and those were the only goals, it made sense to work with fishermen, because we needed to catch turtles in the ocean. We needed a boat to do that. We needed nets to do that. We needed reliable information about where one might go to catch turtles, and I wanted to do that in as many locations as possible throughout northwestern Mexico. So having a boat, and learning through trial and error all of what one would need to learn, was not practical. Working with people who'd spent their lives on the water – not only on the water but catching turtles, because that's what people did – it seemed like the best way to go. So next thing you know, we're working with a lot of people who would be called turtle poachers, if turtle catching was illegal, and they'd be called turtle hunters if turtle catching was legal. That inflection happened in 1990, so many of them consider themselves turtle hunters, and this illegal business was just a recent inconvenience. So those relationships became critical too. The more I learned, the more I realized that some of the research was going to be very useful, and some of it was going to be kind of an excuse to be in the field learning about everything else, and for the social side of things. And, it sort of goes on from there.

I think we did something early on that set a nice stage, which was to go and…. I remember sitting around a campfire – we were diving in Mexico, Jeff and I and a couple other grad students, just sort of for fun – and we were camping, and we had some tequila, and I said something like, "hey let's go and drive the whole coast of Mexico and visit every single turtle project, both coasts," and Jeff was like, "that sounds great," and then we passed out. And the next morning, the first thing I said when I woke up was, "I'm serious, I want to do that." And he was like, "alright, we'll take my truck." It was an old Land Cruiser. So then that was what we were doing. We were mounting this tequila-induced expedition – not that we were going around drunk all the time, but that's where the idea came from – we decided to do it, and we did it. So we left Tucson, and we drove through Texas, and we filed the paperwork for the IRS to create a non-profit in Brownsville, right before we crossed the border, literally sitting at a diner filling out the application to become a 501c3, and it was like, "ok, mission statement – what's our mission statement?" And we'd have to write down our mission statement. "Who are our board of directors?" So we just filled out the form, dropped it in the mail, and then drove the whole coast of Mexico over the next three and a half months.

We went to every turtle nesting beach project along the coast, and at each one we asked people if they could give us a recommendation and an opening to the next one, which may have been a few kilometers away, or may have been a hundred kilometers away, depending where we were. We ended up visiting 52 different research projects, and camping and helping and washing dishes, or working on the beach, just showing up as volunteers, and wide-eyed students. And that created a social network, and that social network still is very valuable. Part of what we do is helped by that ridiculous approach, that we still joke about with colleagues who are now in charge of agencies in Mexico, "remember when you guys showed up in that truck, with your stuff on the roof, and your dog? That was pretty ballsy." And we're like, "yeah, I guess." But that shared story…. And then the word that these two gringo students were making their way around the whole country, news that we were coming started extending further and further ahead of us. And we didn't know that, but, the people who were friends and colleagues with each other in Mexico started saying, "hey, these guys are coming. They're probably going to show up at your camp eventually, and just to let you know, they're cool." I think that probably helped in ways that we'll never even know.

They were mostly Mexican programs, there were very, very few Americans or international researchers, but mostly university, government, or NGO projects in Mexico. And almost entirely working on nesting beach projects, as opposed to the work that we were doing, which was not nesting beach work, it was all in-water. And so the distinction between nesting beach and in-water work at the time, very few if any people were working on sea turtles in the ocean along the coast of Mexico. And that's what we wanted to do, was pioneer – the turtles spend 99.9% of their time in the ocean, not on the beaches. But 99.9% of the research was being done on the beaches. There's just an obvious opportunity there to contribute quite a bit to the understanding of these animals. So that was our focus.

And so we went around to all these projects, and they were mostly Mexican organization or agency-run efforts, some of them – very few – could be called community-based. And that was the stand-out learning from that trip. In particular, the community-based work in Michoacán with the black sea turtles was fascinating to me[3]. It was like, well, these guys *get* it, and they're so far ahead in terms of working with the communities than basically anybody else. I saw that as a huge benefit, that they had a huge leg up in terms of sea turtle conservation. They're doing great research, but they were involving the local community in ways that was at the time kind of unprecedented. Not only unprecedented, but not appreciated and actively opposed even. The idea that you would involve fishermen in saving sea turtles, or community members on the nesting beaches, was not in vogue and it just wasn't part of the conversation. So they were ahead of the curve on that, and just doing it kind of quietly, but formally. It was part of the approach, and I had a lot of admiration for our colleagues working in Michoacán and the community members working with them, and that relationship has grown since then.

I first met them <*who, specifically?*> on that trip around Mexico, but we may have met at a conference prior, and of course everything that they had written up to that point I'd read, many times. And there was a guy – this is an interesting story – there was a guy named Kim Cliffton, who was sort of a cowboy, just a legendary character in Mexico, but he's American, married a woman from Michoacán and spoke perfect Spanish, could fly a plane, could take a truck apart and put it back together, carried a gun, not particularly academically inclined to the frustration of some of the people who work with him. But he really saw what was going on with the black turtles in Michoacán and decided to intervene before the government did. And he did it in a pretty Clint Eastwood kind of way, but had the respect of the people he worked with in Mexico – he's a unique character for sure. He kind of got things going in the early '80s, maybe late '70s in Michoacán[4]. And then the University of Michoacán folks, together with the communities, carried things forward. I think he needed to kind of keep moving, because of the way he approached things.

We tracked him down – he spent some time in Tucson, and we had the chance to chat with him a bit, and be encouraged by his words and experience and all the things that he hadn't been able to do that he still wanted to do… he's a bit of a wild man. At the time I think he was working with the Tarahumara communites in Chihuahua, and then spending time up in Alaska. He's one of those guys, really bigger-than-life kind of characters. So we were really happy to have met him, and gotten the green light in terms of continuing some of what he had started. That's part of it, for sure, and we were

[3] See: Alvarado, J. and A. Figueroa. 1991. Recovery of the Black Turtle in Michoacán, Mexico: An Integrated Conservation Approach. Marine Turtle Newsletter 53:1-3. Online at: http://www.seaturtle.org/mtn/archives/mtn53/mtn53p1.shtml

[4] See, for example, Cliffton, K., D. O. Cornejo & R. S. Felger. 1982. Sea turtles of the Pacific Coast of México. In: K. Bjorndal (Ed.). Biology and Conservation of Sea Turtles. Smithsonian Institution Press, Washington, D.C. pp. 199 - 209.

fortunate that he was in and out of Tucson, so we did get the chance to chat with him. And then there's another guy in Tucson, named Richard Felger[5], who's a brilliant botanist, he's done a lot of ethnobotany work and got involved in some sea turtle issues along the way, so we were able to learn from him. He's a bit of an iconoclast himself, so, it just kind of all lined up. He's based in Tucson, and is one of the world experts on desert plants[6], and he's slightly outside the academic system, enough that he could offer radical bits of advice and encouragement. So, those two guys were – I wouldn't quite say mentors, but encouragers, and interesting characters to us as young scientists, like, "those guys are – wow these guys are published and stuff."

So along the way, we were looking at all these communities, having this realization that knowledge alone isn't going to save turtles. The idea of community-based conservation was relatively new, and not necessarily popular. The idea of involving fishermen in particular, is not popular, especially in Mexico.

So the starting point in any community – so there's a community where people are living and eating turtles, and went from hunting them to poaching them, because of the law changing. And then, I show up. And then what? You know, then what? Who do you talk to first? Where do you go first? Generally the first people to start working with, I would characterize as people like me. So, who in the community is surviving in the community in part of it, but also curious about where turtles go when they go away? Thinking about it, that was always who – if I was born in this town, instead of where I was born, and was growing up in this town, and assuming I was still a curious person with an affinity for checking things out, and learning about nature, which I was as a child – not because my parents were, it just was the way I was, and I've come to learn when I met my biological family that they were too, so maybe there's a genetic basis of that, who knows, or maybe that's just the way kids are. But where's the fisherman who likes to watch the Discovery Channel? And wouldn't mind having a biologist in his boat? And who may want to share what we're doing with their kids?

Each community had a few or many people who – I wouldn't say necessarily that they were leaders, but in some sense they're leaders – and oftentimes they were leaders of their fishing co-op, or other aspects of their community – but who are the open-minded curious fishermen or poachers. Usually those were the people I'd start working with. And usually those were the people I would be directed to. "Oh hey, you know who you should talk to? So-and-so, they like that kind of stuff." And then I'd end up sleeping on their floor, and we'd eat dinner together, and they'd on some level feel sorry for me, I think.

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[5] Ibid.

[6] See Felger R, Felger MB. People of the desert and sea: ethnobotany of the Seri Indians. Tucson: University of Arizona Press; 1985.; Also, Felger, R., and M. Moser. 1973. Seri Indian pharmacopoeia. Economic Botany **28**:415-436.

And concerned that I was going to get into trouble if I didn't have a little bit of help, because I knew nothing about where I was, and clearly didn't know where to find the turtles in this community I'd never been in. And so you find your way, literally into the home of people who are kind of like you, I guess. And that's sort of the sense I got – like, "wow, there's a shared curiosity."

And then flash-forward to right now. So that was the case when I was a grad student, and now, I live in a mountain lion hotspot, and the local researchers and grad students stay at my house. And I feed them, and give them coffee, and a bed. And as much as possible, I participate in putting dead deer in the backs of the traps and learning about the mountain lions. Literally, our house is – if you look at the home range maps, it's like, "whoa, your house is in the middle of the hotspot." Which is really cool, and a little freaky with kids and dogs, and chickens, but it was like, "wow, I am…." I've thought about it this way, from being the visiting researcher conservation guy in communities, and finding people who may think that what we're doing is kind of cool, and may be interested in that initial conversation that goes something like, "I don't want turtles to go extinct, because for whatever reason I love them, as a scientist, or as an ecologist, and as a person," and you don't want turtles to go extinct because they represent your future and your kids future, and you like them, you like to eat them, but also you don't want them to go away, because it takes away one more possibility for the future, whether that's ecotourism, or sustainable use, or whatever it may be. And, it turns out, most of the people we worked with initially, also don't want – they don't want them to go extinct for, you know, just sort of, "that's just not right," kind of reasons. That would be bad for just more existential conversations about animals disappearing, not just not being good for us. Not being right.

So these conversations are with people who are like physically made of turtle, about how wrong it is to drive them to – at least to local extinction – and having complete agreement, and then kind of saying "ok, well what are we gonna do about that?" Like that, you know, "I've got some ideas, certainly not all the answers, and maybe, hopefully, you guys have some ideas, and maybe some of the answers," in those conversations, literally occurring sometimes in the presence of a dead turtle or turtle tacos or turtle soup, and just kind of, getting that conversation going. But it always starts with somebody, and I can name all of those somebodies who in their communities were the pioneers, I think I would say, making the change, and are still attending the Grupo Tortuguero meetings, still doing the monitoring work. And sometimes since I've made a career of doing this work, or a supplemental career.

There's a guy in Lopez Mateos named Victor de la Toba, who's the third generation lighthouse keeper – which is significant because he sort of holds a position of authority, a non-political position of authority, and non-church related – and we started working on a sea turtle project with him, which involved really counting dead turtles. They're washing up on the beaches, because they're being killed by fishing activities. And I asked him, "how do you feel about being the guy who's counting the dead turtles and then presenting the information in public?" And he kind of bravely said, "well, we should know what the truth is, and we should share it, because we won't be able to solve the problem if we don't." Right? Right on. Good answer. Yeah, I can work with that, that's good. And I added, "by the way, if there's anything I can do to help you not make enemies…" you know, and he said, "well, yeah, we may have to talk to people when they get upset. We'll go to their house and talk to them." Well, great. And we've done that. And that project has hit a few bumps along the way, but it keeps going. And now his son is one of the leaders in that community and on that project, and is a kayak and ecotourism guide, and wants to start his own business. But initially in Lopez Mateos, we worked with Victor de la Toba, camped at his house, ate a lot of meals with his family, and it was a little rough, and it kind of grew, and now there's a huge sea turtle festival there every year, and murals all over town, and the project is just thriving in that community. So you could probably tell a story somewhat like that in dozens of communities. There was somebody who was interested, and then somehow we connected with them.

So we were doing our natural history research and learning about the biology and ecology of the sea turtles, and that was good, and the idea that you collect data and then use that data to manage a species at risk, or an ecosystem at risk, makes sense. But as that was going on, I was realizing that that's certainly not enough, and not just not enough, but the connection between the science and conservation action is pretty weak. Something else needed to happen. And while traveling around and working with fishermen to collect data, to collect DNA and to put transmitters on turtles and learn about turtle biology, I got kind of really in the thick of what's really going on in terms of the threats to the turtles, and what then was called poaching – because a few years prior it became illegal, but used to be called just turtle hunting – and who was involved in it, and why, and why people liked to eat sea turtles, and who liked to eat sea turtles most and where the hot spots of turtle mortality were, and realized that just collecting data on the turtle biology was really just a very tiny – an important, but small part of what I later started to refer to as a conservation mosaic. And so a working model emerged from thinking about solving problems, rather than collecting bits of knowledge.

So that was sort of the general feeling. There we were, running around this northwestern Mexico region, which is about 3,000 miles of coastline, meeting with individual turtle hunters or former turtle hunters, fishermen, in small communities, collecting information but also building a social network, and so the model that came out of that is – if you want to call it a model, it's just bonehead simple – we refer to it as a Conservation Mosaic[7]. It's three parts – it's building a network, acquiring new knowledge or needed

[7] Described in: Nichols WJ. 2006. The Conservation Mosaic: Networks, knowledge and communication for Loggerhead turtle conservation at Baja foraging grounds. In: Kinan I. (Ed). Proceedings of the Second Western Pacific Sea Turtle Cooperative Research and Management Workshop. Volume II:

knowledge, and communicating and sharing. Using different words – relationships, understanding, and sharing. And depending on the audience that we're communicating with, we use different language, if it's a more academic group – the network, knowledge, communication frame works better, and those three things really sort of became important, and I still split my time between those three things somewhat equally.

So that was a shift, I think, in our approach. We were very strong in the knowledge bucket, initially, and that was a motivator as a young scientist. Then as things evolved we became more interested in the other two areas, formally and rigorously. Building a network isn't just running around randomly – we approached relationships and building networks very seriously, and thoughtfully, and perhaps even strategically, although I don't like that word strategic, because everything is on some level strategic. That became this point where that model really became – not a mantra, but sort of a frame that we used to remind ourselves of the importance of all of those three things. You can even look on the Grupo Tortuguero website and it's organized that way, kind of a tool, at least to organize our thinking.

Then, in these conversations with mostly fishermen that I've been working with in all these different communities, they started saying, "well, what are you doing in Loreto?" or, "what are you doing in…?" Some curiosity about, "I know what we're doing here, and it's kind of fun and interesting, but who do you work with in these other places? And what do you do there?" And it turns out people were curious, and out of those conversations came the suggestion of – maybe not explicitly, but came together from those conversations – was the idea of getting all of the people we were working with in all these far-flung places together to talk. As simple as that. And so we decided on a place, decided to meet in Loreto – which was where we caught our first turtle, and logistically it's a very handy town. It has an airport, and it has small cheap hotels, and so that was it. We said, "ok, let's pick a date that doesn't interfere with whale watching season too much, and doesn't interfere with peak fishing season too much, and a location that's logistically handy, and let's let everybody know that we're going to get together." So we started doing that, and picked a date, the last Saturday in January, of 1999. Most of these communities didn't have internet at that point, so we were faxing and calling and driving and inviting people, and saying, "hey, here's what we're going to do," basically, "this is our collective idea out of all these conversations, to meet each other, because I think that could be interesting." So we did that.

It was I think about 45 people in the room, and we basically spent the day updating everybody on what we knew, like research-wise, and listening, establishing a few ground rules which was basically everybody's invited who cares, for whatever reason, about sea turtles, and everybody has the same vote and voice, whether you have a PhD in

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North Pacific Loggerhead Sea Turtles. March 2-3, 2005, Honolulu, HI. Western Pacific Regional Fishery Management Council: Honolulu, HI, USA.

something or you're a turtle hunter. Same vote. So that was interesting, and it hadn't been done before, and again it was sort of not popular to bring fishermen together and suggest that they have any say in anything. So the established academic community in Mexico was not that supportive, or not that interested. The government agency folks really weren't all that interested, because the topic of the black market turtle trade was not – was potential, the sore point. But we did it, and at the end of that meeting we voted on the name of the group, which is Grupo Tortuguero. It translates to Turtle Group, very creative. We steered away from – in Mexico and in the US, big long unwieldy acronyms seem to be very popular for some reason. We purposely didn't want to do that, and we talked about that a bit, because it would just send that signal that this was business as usual, and somehow be exclusive, or – so we picked a name that was the opposite of that. And which has held up well, but – turtle group – so in English, the acronym would be TG, and in Spanish the acronym is GT, and that kind of has a cool ring to it. You know? GT, it's just kind of, something sporty about it. So Grupo Tortuguero was officially formed and we all voted on whether we should meet again. And it was unanimous. People thought it was a good idea.

The whole thing cost 1200 bucks – gas, food, and hotel rooms. Basically we invited people and said we've got 15 dollar a night shared, maybe massively shared hotel rooms, tacos – pay for your own beer – and gas money, for those who requested. And some people stayed with friends, some people hadn't been to Loreto in a very long time but had family members there, or friends, and some people had places to stay. Those who needed a place to stay we offered to take care of that, in a very modest, frugal, but respectful way. We did a lot of things right in retrospect, and not because we had done anything like this before, but because we took a real feet-on-the-ground, practical – I don't know how to describe it exactly, but – it was very thoughtful, I guess. And not overstudied, necessarily, but things like holding the meeting on a Saturday, beginning things on a Friday evening so people could fish on Friday, get cleaned up, and then travel to Loreto and show up for dinner. Just keeping in mind the schedules of the fishermen. Meet all day Saturday, have a nice event Saturday night which includes an award presented to the community that's doing a lot for sea turtles, half-day morning workshops on Sunday, and then everybody kind of starts saying goodbye around mid-day, to make it back Sunday to get some sleep to fish early Monday morning. And that's been the basic design of the meeting for 14 years.

The 14th meeting is being held at the end of this month. It's always the last Saturday of January. That was put in place because the group of people that makes up the group don't carry around day planners or PDAs, you know smart phones, or didn't at the time. Now everybody's got a cell phone of some sort, but it's very, very easy to say, "when's the meeting?" "Well it's always the last Saturday in January." That's it. That's when it is. You can remember that. And for the first ten years it was held in Loreto, and now it's being held in La Paz, for all kinds of reasons, but people knew it was the last Saturday in January in Loreto. And now they know it's the last Saturday in January in La Paz.

People come from all over – from Sonora, and increasingly on down the coast of Mexico. It's probably, I'm going to guess, around 40 different communities that are represented. And over the years, people from other regions have come to basically absorb the approach, and learn about it, and talk to people, and then take it back to where they work. So people from Cuba, people from Japan, people from Guatemala, from other parts of Mexico, have come to learn and share, and present. The design of the meeting has evolved a bit, but basically Friday afternoon to evening, there are some technical science presentations, and then Saturday most of the day is filled with community reports. Depending on how many communities are reporting, the time is chopped up appropriately – you have somewhere around 10 to 15 minutes to give your update. And there's an attempt to suggest what should be covered in those updates. There are people who come every year, and so they read off a bunch of data and then say, "any questions?" And then there are people who have acquired PowerPoint skills – some of the guys that present are former turtle hunters who never ever touched a laptop, and who now are presenting their sea turtle data on their own laptop with a PowerPoint presentation they've put together, and it's a very cool thing. People who come from, who haven't come to the meetings, sometimes come and cry, because they're just touched by just the care and the transformation – the scientists who are a bit jaded by these scientific meetings that we all go to. And then they meet Julio, who tells his story, masterfully presents it, and it's like, "... wow, that's the best presentation I've ever heard."

So, the meeting was kind of humming along and evolving, and growing quite a bit – we went from 45, to doubling every year for several years – and about nine or almost ten years ago we used that network as a base for creating community-based sea turtle monitoring project. We got some funds and some equipment, and did some training, and set up teams at each of these locations – I think there are a dozen of them now, initially there were six – locations where we wanted to see monthly turtle monitoring, in-water sea turtle monitoring going on. And that's been pretty interesting, just knowing without Earthwatch, or American researchers and foreign researchers being there – the idea was to get the permits and the methodology and the equipment, and some modest funding, so that community leaders would take on the role of doing the research, essentially. And that was really cool, and that's ongoing, and it's grown in a number of sites. That data is brought together at another annual meeting that usually occurs in the summertime, and summarized and put together as an annual report. That's been the raw data for several master's theses, and serves also as another kind of network, so that if a researcher comes along and says, "I want to study barnacles on sea turtles," they don't need to go set up a sampling project at a dozen sites, they can just plug in to this mark-recapture monitoring project. Or if somebody says, "I want to study the blood chemistry," for whatever reason, of sea turtles in northwest Mexico, they can do that.

And it's also been the base of some ecotourism. Now some of the teams are bringing travelers, visitors or tourists, along with them to help, and that funds the research and funds – in some cases it supplements the incomes of the people doing the work. So that's sort of moved a little bit towards being a sustainable research project. That's not self-funded but funded through things other than grants. And some of the people who visit are from Mexico, they're from the region. We've done some analyses showing that people who live in La Paz, who've never seen a turtle, might love to go out to Magdalena Bay and spend the night, and catch and tag turtles, and go home the next day. So the domestic or local eco-tourism is a huge market, there are people with the financial means to pay something to go and do that, and we shouldn't overlook that. That's often the case, "oh, bring travelers from Europe or the United States and they'll pay a thousand dollars to be in the boat," and that's great. And there are some people down the road who would pay a hundred dollars to be in the boat, and you don't need to put them on an airplane. It's even more exciting, to me, when that happens.

So that's one of the outcomes of Grupo Tortuguero, is to create this monitoring project. And it turns out most of the sites are in some sort of Marine Protected Area. So now you've got community-based endangered species monitoring and research within MPAs, and when some of the official people looked up and saw what was going on, they said, "whoa, that's an amazing thing. That's what we talk about, but haven't been able to implement." In theory, there's a lot of discussion of community-based or participatory work to do within Marine Protected Areas, or protected areas in general, and that's a goal. And here it's been going on for over a decade, and kind of happened without a lot of fanfare, and without a lot of funding, just by being kind of thoughtful and practical, and really looking for smart, efficient, and so much – common sense. But if you step back from it all and you kind of go, "how should this go?" This makes the most sense. People who care about and live in a place take on – make a living at, or involved in, studying and stewarding and protecting these animals. Makes sense.

And so the Earthwatch volunteers and those initial grants kind of got things going. Once we got some momentum we could get some money from some agencies and foundations to keep things going, it got a little bit easier. Even though our first grant from the Packard Foundation – I remember clearly the project officer, Sergio Knaebel, who's now at the Sandler Foundation, he said this, "I'm going to fund this, but I don't think it's going to work." I think he was in that camp of, "it's too late, you're not going to be able to organize turtle hunters to become turtle protectors. But, hey, you know, we're going to give you money to burn." And he's told me since then, recently, that he thought that was like burning money, that grant. He had the discretion to take a few wild leaps with a few small grants, and it was considered one of them. And little did I know. I mean, I thought it was – it was a confidence builder for me, and it was burning money for him. So I thanked him for not telling me at the time that they thought it was burning money, because that would have – it may not have undermined that confidence, but it wouldn't have helped.

But I forgot to mention that at first we basically sold everybody we knew a T-shirt, and funded things that way. So before Earthwatch, we fundraised by each – Jeff and I each put in a few hundred bucks and then we went to the local T-shirt shop and said, "what are your cheapest T-shirts?" They took us into this back room and they're like, "these are the cheapest T-shirts." They were all of the worst colors that nobody wanted. Sort of pea green, and this weird pink – just all these bad colors. Not quite day-glow, but faded day-glow, like pastel-y day-glow colors. Like light lime green, and… so we bought them all. And we were like, "well, ok, here's our design, and we want as many T-shirts as we can get for 400 bucks." And they took some pity on us and they printed them for free, and we sold them for more than we paid for them, and then took that money back and made more. And we turned enough over to put a few thousand dollars into our research fund, which was enough to get us out the door and start learning. We had some cash to eat and move around, in the '72 – I had a '72 truck and Jeff had a '73 Land Cruiser, and so yeah, a little bit of money to keep the maintenance going and put gas in the tank, and buy tacos and move around, talk to people. And grad students I've met now, they complain that they're waiting for their 40,000 dollar grant, they can't do anything. I'm like, "did I ever tell you this story…?" They're like "yeah, yeah." They roll their eyes, they know they're getting zero pity. You go to the store, you get a big thing of peanut butter, and some bread. And you sell some T-shirts and you start. That's the way you get going. Anyway, that is how we started. Jeff's girlfriend at the time designed the T-shirt, it was like this Aztec and sort of sun dial design with turtles and moons, and it says *Projecto Tortuga*, turtle project – no website, just the name. Many people around the world have them. Whether they wear them or not is another story.

The first expeditions, I guess you'd call them, in Baja and in northwestern Mexico, I was coming at it as a young grad student in a science program, so the motivation – at least on paper – was to collect data to study turtle ecology, to study migration, to study genetics, rather than build a movement, which would have been a weird thing to say, and probably unacceptable, politically, at the time. Things have changed quite a bit, in a lot of ways – you can look at A.J. Schneller's paper[8] and how things have changed, and how the turtle project has changed things for more than sea turtles, opened up and made some room for just the very idea that we can work with fishermen and solve problems and build grassroots movements and organization. And this particular one carried the turtle flag, but that really was – and still is, oftentimes – kind of the excuse. It offers a bit of

[8] Schneller, A. J., and P. A. Baum. 2011. The Emergence of Associational Life in Mexico's Wild West: Pioneering Civic Participation, Sea Turtle Conservation, and Environmental Awareness in Baja California Sur. Voluntas: International Journal of Voluntary and Nonprofit Organizations **22**:259-282.

cover to say, "hi, I'm a scientist." Ok, that makes sense. "Hi, I'm here to save turtles," huh, I don't know. Then a wall goes up. And not in a sneaky or dishonest way, but….

You know, I talk to students now, Mexican students and American students, it's like, "a lot of this stuff that's really important is not necessarily going to be in your proposal." And you know, the student who did her master's work on turtle movement within a branch of Magdalena Bay, in comparing their movement with the tides, and learned some pretty interesting things that were completely unknown about sea turtles in general. And the lasting benefit, I guess you'd say, or the lasting part of that work, has to do with the relationships that were built, the people who became interested who live in that town who are now still involved. Who tracked turtles all night by kayak, who hadn't done any kayaking before, and built camaraderie because they're up all night tracking turtles for weeks and weeks and months and months. And so that knowledge quest is still important, and it serves a whole bunch of other purposes, and it sort of makes – the pursuit of knowledge is a legitimate reason to be showing up, then people get it. And it's a starting point oftentimes for building the network, and for sharing other kinds of information.

You know, when I present the mosaic it's three circles that are very much overlapping. And the reality of the network is that those relationships are critical to your communication and your sharing, and so your sharing works because you have a network. It works better when your network is strong, diverse and large, and so does knowledge. So it's kind of like we're spinning around in this thing, and it's very much overlapping. I've become more interested, even academically interested, in the social change literature and network analysis literature and social dissemination theory, and the math of networks, and the science of networks, and more recently Nick Christakis' work and stuff going on at UCSD, how we influence each other. And then you bring in the neuroscience of it all – it's fascinating stuff. And that wasn't available twenty years ago, as a basis for the way we were thinking, but we were doing it – I mean it's really exciting to kind of go, "oh, yeah. They're learning about that, and that's what we were doing, just because – we got it right, in some ways." Because we took the time, I guess, to think about it. So, when we were talking about network, knowledge and communication, they're very much overlapping, and one realm of the knowledge is communication science, and network science. But at first, our knowledge quest was turtle science.

And then that started to expand, and you can see in some of the things that have been published, you know education science – what do we need to know about how to share, in order to share better? What knowledge do we need about building networks, in order to build networks better? It turns out that having access to that network as a researcher, even if you're doing social science or natural science, is powerful, very helpful. If you were to pursue a study on social sciences, grassroots conservation in Baja, you could spend a lot of time figuring out where to go, who to talk to, but or you could plug into this network and find, at the very least, a place to stay in every community that you wanted to do interviews in, and a hot meal. So that's really helpful. Any question you may have about turtles or people, that network can serve as a base. And when you have something to say about what you learned, that network can serve as a way to get that information quickly into the hands of a lot of people who may be able to use it, or appreciate it, outside of the colleagues in academia.

As a grad student, from the home base, the mandate was, "go learn something new, and come back and publish it." You know, that's what people in academia do. And my committee was much less interested in the movement building aspects, and the human relationship aspects, and they said, "you know, we know you're going to do that, apparently you're going to do that stuff, just don't put it in your thesis." Because there wasn't a, you know, people just didn't have these conversations. The conversation that we're having now is, we're having it in – you know there's an academic base to it, right? But that wasn't – this conversation wouldn't have been appropriate at least in that department, and as far as I could tell, in most departments. It just wasn't – we weren't there yet. A rigorous conversation about participatory science, participatory research, or citizen science, wasn't going on in the world. We were still doing it, for really good reasons, but it wasn't acceptable back at the academy. We just did it anyway.

On one hand, you know, a very personal, selfish motivation was, "I want to get my degree." There was that, and all the stuff that comes along with that – like the hoops and hurdles, and you know, you need to have your work plan approved, and you need to slip a tome of a thesis past a committee, so there's that going on. And you get sucked up in all the research-y stuff. But my interest always – and if you'd asked me when I was 12 – my interest is solving problems, not publishing papers. And, you know, if publishing papers helps you solve a problem, great. But it's not – I'm not that interested in the academic game. The publish-or-perish thing is not appealing at all. So if publishing your research with a local newsletter helps solve the problem, then let's do that. If publishing it in a high-profile ecological journal helps, well, let's do that too. I look at the academic publication process as a tool, not as a goal or an end. So, a lot of times when we publish papers, we've gone along, knowing that I wasn't really headed into a tenure-like life, if it's in academia, I'd say to my students or colleagues – I'd like to be last author, because I don't need to be first or second author. So, that – it may be good for them to be in a more senior authorship role, because it would help them get a job, and get into a position where they could have more influence. So, there's always this practical approach to that stuff too. Solving problems is definitely – I signed up to solve problems. What else are we doing here, you know?

And it can be frustrating a bit when these two parallel paths don't – sometimes can be in conflict a bit. You're trying to get your degree, and your committee is not necessarily interested in how people feel, or building a grassroots movement, because it doesn't fit into evolutionary biology very well. Or we didn't think it did, it actually does, but that's a whole other conversation, with recent work on bringing neuroscientists into the conversation. I think one of the realizations was that change happens on a very personal level, usually for very emotional reasons, and that policy, law, information, and even money aren't everything. There's a whole bunch of stuff that makes up our lives that isn't about money or laws, or rules, that makes up most of our lives – everything that's sort of free and important. So taking this small area of interest in the world – it's relatively small, restoring sea turtles – it's a good idea to understand the part of life that has nothing to do with money, that has nothing to do with law and policy, and makes up most of my life really, and most of the lives of, at least most in terms of most important, parts of our lives, have to do with our relationships, and those aren't about money, they're about stuff you're not allowed to talk about, like love, and happiness, and dignity, and pride, and fear, and a whole long list of emotions, and I'm just kinda saying that stuff's not off-limits – fun, how about fun? And so the Grupo Tortuguero meetings, and even our research, has always been about fun, and love, and friendship, and singing, and music, and turtles and science and ecology and hard work, and reasonable ideas, and – but all the other stuff too. And that's why people like it, I think.

And this – the realization that we're asking people to do something, give up something, that in many ways is important to them, and if you're not offering something good to somewhat fill – not necessarily replace, but sort of occupy the space you're asking people to give up – it's definitely not going to work. And it isn't just money. In conversations with poachers, they'd say, well, just a hypothetical situation, "if there was a job that paid just as much as you're making by poaching, how would you feel about that? Would you take it, and give up poaching?" And usually the answer was no. Because it wasn't about just the money. And the economists that we've worked with – economists have come to Baja, to help – and they don't always get that. You know, there's a lot more going on inside of us than just our drive to collect money, but we kind of reduce it to that in laws and policy and economics. So my degree from Duke is in Economics and Policy, and then what? What about all the other stuff? Economics, policy, and love it should have been. Yeah, fat chance of that. But that – it's true, that was my learning process in Baja. It's like, "wow, there's so much more to this." It's fun, like, wow, these poachers actually like going out, and living on the edge a little bit.

So in each community obviously there's an initial point of contact – usually that person is someone who is basically interested in the subject and happens to be a fisherman. I'd say somewhat organically, when you are doing something different somewhere, it draws some attention, and inviting new people to participate is always our approach. But you have to really pay attention a lot to the interactions between people, non-verbal communication particularly, because the verbal communication is in another language, the subtleties are easy to miss. In order for things to work and to grow within a community and for more people to get involved, there's always local politics and existing relationships between individuals. So you may think, "oh, that's how these people are doing this," and not know that they're bitter enemies with the people you're working with. Or there's some history, or… so, that aspect of it is really – I've never really discussed it with anyone, and there's certainly no training in that, wasn't for me, I wasn't aware of anybody suggesting that you consider that reality when you're interacting with people on a conservation project. But all those little subtle things about people getting along or not getting along – if you're creating a team to take care of sea turtles, it's a big part of it, it turns out. So, that means you have to put on the Switzerland hat, and try to – sometimes it's helping people resolve their disputes so that they can sit in a boat together, literally.

Being an outsider who is apparently never leaving, just keeps coming back relentlessly, and who's a little bit weird, in terms of their interest in turtles – it just worked, I guess, looking back on it, creating movement buy-in I guess you'd call it, or interest in a community, extending to the heads of households – who are usually women managing finances and managing households – to school teachers, the head of the school, head of the co-ops. They become engaged in sea turtle protection and fisheries management, reduction of illegal activities. It's a bit of a delicate dance, but it happened. I could probably describe in different communities how smoothly or roughly it went. It's interesting, the evolution of say, Magdalena Bay. There are four brothers that were forming the core of the sea turtle team in the early days, and they gradually moved on to do other things, and replaced themselves or recruited the next group of people, and that's happened several times. As a result, you've got people all over town who at some point have been part of the core sea turtle research team who are now doing other things, but also carry those experiences and stories and sometimes magazine articles about their work or documentary films that they're involved in or have a connection to. And they carry that with them. They're sympathetic to the goals, and personally supportive, sometimes in ways that we don't ever know about, like releasing a turtle, or having a conversation.

I started calling this work full immersion conservation a long time ago, and we use that phrase still, because I think the citizen component of it is important, but there are lots of other components. I mean, certainly the scientists are … I don't know, "citizen science" can confuse me a little bit, because I don't know who's not a citizen. I know what it's meant to mean, but – so the opposite of citizen science would be, "illegal alien science?" I don't know. But semantically I struggle a little bit with it. Our approach has been to invite everybody, to fully immerse them. Sometimes you get really involved in people's problems, and in one case there was a guy that was described as a poacher who was an important part of our team, and his wife is diabetic and he needed some medication that she required, and they couldn't afford it in Mexico, but it was a third of the price in the US. So I got involved and immersed in her health care, and was the guy bringing the medicine, which ended up probably saving her. Saved her eyesight. And that connected us personally. You start breaking all sorts of rules of academic research by being fully immersed, and that's just one example. But I think that's kind of the description, so that you know the science is one part of it – it's an important part of it but it's just one part of it – and being a whole human being interacting with other whole human beings towards a common goal, and helping each other, you know, what do you call that? Full immersion, that's what it feels like. And, I'm still immersed in it, although I don't spend as much time in Baja now as I used to. So, that's not really a technical term, but it's the one we use.

The end of this month is the 14th meeting of the Grupo Tortuguero – that's 14 years on top of the ramp up to forming the Grupo Tortuguero. And that's exciting, but what's really exciting is that the black turtle population is going up. It's working. So we've talked about all of the process, but it would be sad and maybe less interesting if the conclusion was, "this shit's not working. It's really, really interesting, and we can talk about it a lot, but it's not working." But that's not the case. Where the communities have been engaged, it is working. The edge has been taken off of the sources of mortality, allowing turtles to be turtles and reproduce, and we're seeing more and more of them. And that's a positive feedback loop, so far. There is a possibility of decision-makers saying, "ok, congratulations, now we'll open up the legal turtle harvest again," but it's interesting, there's a lot of people who are potential beneficiaries to return to turtle hunting who would probably say, "no, we don't think we should do that." Former turtle hunters who would say, "that would be a bad idea, based on what we've been doing for the past 15, 20 years, and what we now know. We don't think legally releasing that ban on turtle hunting would be wise." That's interesting too, because now you've got this group of advocates who are not just academics or activists, but are activists and former turtle hunters.

They're citizen scientists now, as well. And they understand – they've measured turtles for a decade or more themselves. They can give you the name, the number, and the data on the turtles they've caught, and recaptured, and they've seen how some of them don't make it, because there is still black market poaching going on, and that if there was more, then it would be worse, and the population would probably quickly go back to where it was. They've measured growth rates of individuals – and they don't grow very quickly, they're slow-growing, late-maturing animals – and that concept is not a PowerPoint slide anymore, or something in a book that you say, or something that somebody tells you. It's something they intimately know, and can lecture on, literally. If you say, "teach me about turtle growth and population," they will give you a damn good lecture with their own data on *r* vs. *k* – they might not put it in these terms, but – *r* vs. *k* selected, slow-growing, late-maturing, long-lived animals like sea turtles. And that's the way they work. And taking too many of them quickly puts them in jeopardy, like sharks and whales and other big, slow-growing animals. That's something you can teach people by telling them to read something, or lecturing to them, but it's pretty powerful and pretty convincing coming out of the mind of somebody who is a former turtle hunter, and then turtle poacher, and now turtle researcher, telling you about the animals they've tagged and measured and re-captured and re-measured, over ten years.

When you talk about participatory science and what the goals are, science literacy is one of them. And it happens over time, when you take the time to observe nature for a decade, repeatedly over and over and over, going to the same place, and looking at what's going on, and the changes, and writing it down, and analyzing the data yourself, and then summarizing the data so that you can present it in a PowerPoint every year to your peers, who are doing the same thing all over the region, you begin to understand and share and – when that threat comes back and somebody in some office says "oh, we should start hunting turtles again," they go, "well, I've got a point of view that I'd like to share, based on good information." And that's really empowering, you know, and it's really cool, and that connects to dignity, and community and pride, and all these emotions that we don't really know how to talk about.

Another possible outcome is, "these are my babies now, and I've named them and tagged them and I love them," and maybe this is an actual outcome, as it is with animals here in the US, and so that's something that the decision-makers will have to also deal with. And then you bring in sort of the people are making alternative livings from nature without consuming it, so non-consumptive use, and so that's a piece of it. What's happening in Hawaii right now, the green turtles have recovered for the most part, and native Hawaiians want to hunt them again, they want a permitting process to take some turtles, and there's a big huge backlash. And you do have to consider the image issues for Hawaii, for Baja. Baja has sort of decided in some ways to take on this image of a place where we protect turtles, where you can come and see them and enjoy them without eating them or their eggs. And that has value.

And if you go down that road, then it's probably not a good idea to also permit some sustainable harvest. That's one of the prices I think you might pay, is that's a bit of a mixed marketing message. It may be navigable, and it may not be. And I would imagine probably not, because – especially these days where communication is so fast, and if a tourist is – goes turtle-watching and then is walking down the beach and sees somebody barbecuing a turtle, they pull out their iPhone and now you've got a conversation about that, if not a problem. So, it's an ongoing swinging of the pendulum, I suppose.

I think turtles innately have – there is a biological, ecological problem with turtles and sharks being used at any scale as food. They're pretty sensitive – because they're slow growing, and late-maturing animals, unlike say sardines – and ecologically you quickly get into trouble if you take too many big slow-growing animals, and then it takes decades to rebuild them. But I think the reality is that there is a black market use of turtles that is alive and well. And in some ways you could kind of say, "well, that's our system of beliefs," is sort of – you know it's there, it's happening, and the government did not condone it, it's very – it's become more clandestine, therefore fewer people do it, because it's harder. And those people who really, really, really, really, really, really, really want to eat a turtle, they figure out how to do it. And they do so quietly, more so than they used to. And so, it's kind of like, everybody's happy, right? And the turtles aren't gone, which by now they would have been really toast, if what happened didn't happen.

One of the insights from a recent trip to Baja that I was really excited about, and I spoke about it at a science meeting, where mostly scientists at one of the universities where all the current research was presented, prior to the Grupo Tortuguero meeting with more of the community members. Formerly those things happened together, but as Grupo Tortuguero has grown, the science has continued to expand, and a lot of the scientists don't really want to hang out with the fishermen. That kind of made me sad, but we were able to create a structure where a summary of all of what was presented in the pre-science meeting was shared at the larger community meeting, so there was a depiction of the science during the community, the open community meeting. But one of the observations that I made at the science meeting, and then again the next day, was that by whatever measure you want to do it, sea turtle science per capita is probably the highest of any place in the world in Baja. We've really produced a massive amount of research on just about everything you could imagine studying about sea turtles, and peer-reviewed. It's in Masters and PhD theses, and it's presented at conferences around the world, and it's just a massive pile, and so the density of research in that region is enormous. And I'd say almost all of it, including the lab-based stuff, has required citizen science or participation of communities, community members and fishermen, in one way or another. So that's remarkable, by our strict measures of quality within academia, given those constraints and the peer-review process and so on, this model has produced some of the best sea turtle science in the world. I'd put our bibliography against sort of Australia or Florida, or anywhere, as far as quality and quantity[9].

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[9] The "bibliography" J. mentions is virtual and not compiled. As there is not a keyword standard (e.g., Grupo Tortugero) to indicate the relationship to this network, it is difficult to retrospectively assess the scholarly work stemming from this network. A small selection, representing diverse inquiries, includes:

Koch, V., W.J. Nichols, H. Peckham, and V. de la Toba. 2006. Estimates of sea turtle mortality from poaching and bycatch in Bahía Magdalena, Baja California Sur, Mexico. Biological Conservation **128**(3):327-334.

Senko, J., A.J. Schneller, J. Solis, F. Ollervides, W.J. Nichols. People helping turtles, turtles helping people: Understanding resident attitudes towards sea turtle conservation and opportunities for enhanced community participation in Bahía Magdalena, Mexico. Ocean & Coastal Management **54**(2):148-157.

Mancini, A., J. Senko, R. Borquez-Reyes, J. Guzman Póo, J.A. Seminoff, V. Koch. 2011. To poach or not to poach an endangered species: Elucidating the economic and social drivers behind illegal sea turtle hunting in Baja California Sur, Mexico. Human Ecology **39**(6):743-756.

Ley-Quiñónez, C., A.A. Zavala-Norzagaray, T.L. Espinosa-Carreón, H. Peckham, C. Marquez-Herrera, L. Campos-Villegas, A.A. Aguirre. 2011. Baseline heavy metals and metalloid values in blood of loggerhead turtles (*Caretta caretta*) from Baja California Sur, Mexico. Marine Pollution Bulletin **62**(9):1979-1983.

Yet, there is a huge gap between that knowledge and the capacity to use it by the government agencies – the official capacity to take that knowledge and put it into action for conservation – a huge gap. And unlike Florida or Australia or other parts of the world, where there's great science, in a lot of those places there is capacity to take that science and use it in clear ways to create policy, to create action, to create enforcement, to create management plans in MPAs, and fisheries regulations that are enforced. So that was interesting, just to kind of put that out there. And therefore the communities, the network of people that we call the Grupo Tortuguero, takes on a very important role, not just in creating the science, but in implementing actions, and sort of supplants the role of government agencies, necessarily. So the model of conservation mosaic that we use is crucial, I think, to actually solving problems – to creating and reaching the goal, which is to restore populations of these endangered animals. You can't just create the knowledge and hand it off and just expect action from the authorities, because they just don't have the capacity to do that. And so that network, knowledge, communication approach involves the authorities, to the extent that they are able to participate, but doesn't depend on them. And that's really clear when you take a step back from it and look at the body of knowledge that's been generated over the past twenty years, the role that citizens have played in that, but then also the "what's next" part of it, which goes back to the very people who created the knowledge. Not just fishermen and community members, but also the researchers, the NGO leaders, the funders, local businesses who may have supported the project in some way, so that the capacity of that group of people to create protection for sea turtles, that is really where the power is, and not in the offices of La Paz, or in Mexico City. If we keep expecting them to take the reports and the data and turn it into action – it's kind of a ridiculous dream at the moment, and it's been a bit of a dream all along. I think it's pretty clear to people that the way it's going to work is for people to use this knowledge themselves and create movement from it, or action or change or whatever it is they're after.

There was a moment at the science meeting when an important person from the government, after I'd made that point, he said, "I don't have access, I don't have these reports. I need them and I need to read them." And my response to that was not – and I wasn't trying to be flippant about it or disrespectful – but I said, you know "Google Scholar, if you go into Google Scholar and put three words, 'Baja sea turtle,' you'd be amazed at what comes up[10]." And then he said "well, you know, you don't get the full article, you only get an abstract," and before I could sort of defend myself, several other people in the room said that, "that's not true. This community has done a good job of

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Senko, J., M. López-Castro, V. Koch, and W.J. Nichols. 2010. Immature East Pacific Green Turtles (*Chelonia mydas*) use multiple foraging areas off the Pacific coast of Baja California Sur, Mexico: First evidence from mark-recapture data. Pacific Science **64**(1): 125-130.

[10] Google Scholar searches using these terms routinely turn up over 9,000 results. Assessing which of those results stem from research of the Grupo Tortuguero network is difficult. Regardless, a high percentage of the articles are, as J. mentions, freely available as PDFs.

making the PDFs available. New students are able to go on Google or Google Scholar and find a massive amount of background literature publications available for free." And the guy sat down, and was like "ok." It wasn't an attack on him, but the reality is he clearly hadn't tried to find the information ever, because if he'd tried he would have found most of what he needed. He clearly has an internet access point somewhere, and he's a speaker of fluent English, but he sort of unwittingly underlined the point that there isn't institutional capacity or interest. So, that was an interesting interaction.

I think the big picture dynamic – that's the role of the outside guy or gal or both – continues to be interesting. In the past few years I think I very consciously made an effort to fade out a bit and work with, not so much local community leader, but Grupo Tortuguero leadership staff, the Executive Director and the rest of the staff, to hand off, I don't know what you would call it but sort of this authority that I'd been carrying around that I don't want to carry around, and should be handed off. It's a process that's been going on for a few years, of being a little less available, and a little less hands-on, and not around as much, so that the organizations get stronger. And it's a little bit tricky, because it's very personal, there are a lot of friendships, and so that transition has been pretty successful. And now some of the heavy lifting, in terms of fundraising, and maintaining the relationships with funders, and the relationships between sort of the central hub of Grupo Tortuguero and the communities – that's been having its own growing pains I guess.

There's a dynamic that is not necessarily unique to Mexico, but very, very obvious – the story that Mexicans tell about themselves is that there's a bunch of crabs in a bucket, and one of them tries to climb out, and it gets a claw over the edge of the bucket, and the other crabs yank it back, grab it and pull it back in to the bucket. And so the metaphor I guess is as things get good, and there is some success, there's this pulling back and desire to – it's competitiveness, I guess. Grupo Tortuguero is doing well and getting some accolades, then there's this sort of this attack on the Director that was absent when I was in that position – I think partly because of being an outsider, and partly because I just don't compete, I'm not a competitive person, and so when that stuff would happen it just wouldn't get a response. That's a new dynamic that is happening, where the people who see themselves in that leadership role are taking shots at the current leader, in a way that's a little bit destructive, and jealous maybe. So I found myself spending a fair amount of time on this recent trip talking to different people about that – if they're on the side of, "hey, lay off, deliver your critique in a helpful way or chill out," and then talking to Aaron who's the Executive Director now, about how he can handle it and find the useful information in those attacks, which can be pretty hard to do. It's all a new piece of a maturing organization and a maturing movement. I think you see that a lot in progressive organizations, there's sort of a, I don't know, something happens and things… things fall apart. So we're figuring things out.

So I think of being ok with not controlling everything. That's the advice that I give Aaron – I say if you want to control everything, and monitor everything, you can try, but it's going to be very expensive. And probably won't work. Or you can take a different approach and not obsess with the inter-workings, as a lot of organizations try to do. But guide, sometimes just cheerlead or coach.

We have the fifteenth year celebration coming up, and at the closing awards ceremony and dinner, it was my turn to say a few words, and I just said "next year we celebrate the *quinceañera* of this organization," which is traditionally a big party for the 15th birthday of the young woman, to celebrate passage into young womanhood. So that would be next year, and, "... so between now and then, let's take some time and some effort to reflect on what's working and what's not, and work together to make the things that aren't working work." And the tradition is that the parents, the dad of the young woman buys the tequila for the party. So I'm saving up my money to buy some good tequila for everybody.

And that was kind of how we left things. In a way, it was a recognition that, ok, 15 years, this organization is matured, and has some things to work out, as it happens and is always the case with organizations and people. And by buying the tequila I'm kind of saying, you know, "good luck – I'm not leaving, and at the same time I'm letting go." And that's something that's happened already in a way, but certainly in a more formal kind of way that could be at least mapped metaphorically onto the quinceañera tradition. That was the goal all along from the beginning, was to let go. So it's kind of awesome to be doing that, and knowing that there's this good work going on, and it doesn't require as much outside involvement. That was a pretty cool meeting, and I think next year is going to be great.

Karen Oberhauser
University of Minnesota

Focusing on process standards

Karen's ease in sharing her science comes through naturally in this profile, which reads, in part, like a lesson in monarch ecology. In explaining her work with the Monarch Larva Monitoring Project (MLMP), she weaves in explanations of monarch life cycles through what she calls, at one point, a "biology detour." She is tenured faculty in an Extension position, and mentors graduate and undergraduate students through her MLMP work, but many of her education efforts are also focused on younger learners and educators of those youth.

The Monarch Larva Monitoring Project[1] is a network of volunteers, mostly in the eastern half of the United States and southern Canada, who are monitoring the distribution and abundance of monarchs during the breeding season. They do this by going out and checking milkweed plants somewhere near where they live, on a weekly basis, keeping track of the number of plants that they look at and the number of monarch eggs and larvae that they see. And they collect other information about their site, so that we can use the data to look at differences in monarch abundance on a per plant basis, and look at how these differences, or how these numbers change over time, within a season at the same site, between seasons at the same site, and within regions, and how the numbers vary between regions. This gives us a picture of how the monarch population is doing over time, and the importance of different regions and different kinds of habitat to, overall monarch abundance.

Initially this was a project that started with a graduate student's thesis. Michelle Prysby, who started in 1995 or 1996, was interested in basic questions about factors that drove monarch population dynamics. We started monitoring monarchs in our lab group, and then we thought it would be really great to get these kinds of data from other locations and other habitats. So, it started as a question for a thesis[2], we started working out the protocol in our own lab group, and then made it into a citizen science project.

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[1] http://www.mlmp.org/news.aspx For an overview, see Oberhauser, K. 2012. Monitoring Monarchs: Citizen Science and a Charismatic Insect. In: Dickinson, J.L. and R. Bonney (Eds.), Citizen Science: Public Participation in Environmental Research. Cornell University Press, Ithaca, NY.

[2] Prysby, M. D. 2001. *Temporal and geographical variation in monarch egg and larval densities (Danaus plexippus): an ecological application of citizen science* (Doctoral dissertation, University of Minnesota).

The MLMP was focused on straight research in the beginning, but long before that I was engaged with monarch outreach and education. I think a lot of that work started by just getting interested through my own kids. I was at a research associate stage in my career when that all happened – this was when I was doing research on paternal investment in monarch butterflies, basically looking at reproductive ecology of monarchs[3]. I got my PhD in 1989, and then went to a research position at the University of Minnesota. Right after I graduated I had a baby, and very soon after that I received a research grant that was focused on paternal investment, which was a continuation of my PhD work. So I was pretty invested in straight research for the next 3 or 4 years, and raising two young children. The whole Monarchs in the Classroom project started when I had literally hundreds, or probably thousands, of monarch larvae available at the end of the summer. So when my daughter went to kindergarten I just said to her teacher, "do you want a few?"

The research I was doing resulted in a lot of eggs. When butterflies mate, males transfer sperm to the females in this little protein-rich package called a spermatophore. The spermatophore varies a lot in size with the age and mating history of the male, and the female actually uses the protein in the spermatophore in egg production and in her own somatic tissue. So the spermatophore for the male is investment in his offspring, and also the female breaks it down and uses it in her own tissues. So we call it paternal investment, because it's an investment on the part of the male. Now, from the male's perspective, what he's really trying to do with that spermatophore is increase the amount of time before the female mates again. So it's not necessarily that beneficial for it to be used in the offspring, what really benefits him is for her to wait longer before she mates again and starts using some other male's sperm.

I was interested in how many eggs females laid, and I was just counting them and not doing anything with all of the larvae that came from those eggs. Female monarchs can lay 500 to 1,000 eggs, so every experimental female in my studies produced all of these eggs, and I was freezing them, because I couldn't raise that many, and I just felt awful about it. Then I thought, "oh, I bet my daughter's kindergarten teacher would love these!" She was really excited, and all of her teacher friends wanted them too, so that's how I started taking the caterpillars into schools.

And then in about 1993 or 94 Chip Taylor and I got an NSF grant to develop a curriculum centered around monarchs. This was when Chip was just starting his tagging program. We decided to write a proposal to develop the educational aspects of what we were both doing. So, the Monarch Watch project[4] really grew out of that initial grant that he and I

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[3] See, for example, Oberhauser, K.S. and R. Hampton. 1995. The relationship between mating and oogenesis in monarch butterflies (Lepidoptera: Danainae). Journal of Insect Behavior 8(5):701-713.
[4] Based at the University of Kansas, a tagging and recovery program exploring monarch migrations. www.monarchwatch.org

had. I worked on the curriculum development and he worked on the tagging program and started the listserv. We had developed the Monarchs in the Classroom program at the University of Minnesota, so there were already a lot of teachers who were really interested in monarchs. And because I was on the listserv from the beginning, I could really see the growing interest in monarchs throughout the country, and just how interested people were in monarchs from an educational and conservation perspective.

The citizen science connection evolved from these beginnings – not directly out of those programs, because I wasn't even familiar with the term citizen science – but, because I was doing that outreach work and working with a lot of people in the context of my monarch research, I naturally made that connection. Michelle was interested in documenting monarch distribution and abundance over the United States, over the entire breeding range, and I think that's when this kind of clicked in my head –we have all of these connections with people who are interested in monarch education, and they probably would be interested in helping us collect data. It developed from the straight research focus, as well as from our involvement with outreach, and talking to so many people about monarchs. So when a specific research question came along where additional data would be really useful, it really blended those two parts of my life nicely.

Michelle was initially interested in predators, monarch survival, and mortality rates of eggs and different larval stages. We started out estimating mortality rates using a monitoring technique very similar to what we eventually developed for the MLMP, and then got very interested in how those mortality rates might vary in space and time. And I thought well, we really can't go all over the country to do this, but I bet other people would be really interested in helping out with this. We worked to write a protocol that other people could easily do, used the MonarchWatch listserv to recruit people, and soon people were collecting these data all over the country. We started with a focus on monarch survival, and then kind of merged this narrower focus into a study of big scale distribution and abundance patterns and how they change in time.

For a year or two before we started the Monarch Larva Monitoring Project, we had started, as a lab group, just going out to a couple sites near us and basically developing that protocol. We were interested in, for example, effects of habitat, and we had a perfect experimental set-up because we had a site that had a lot of mowing going on, resulting in different ages of milkweed at the same site. We started monitoring a couple of different sites, and it was very clear that we were seeing different patterns in this natural experiment, and at different sites, and that made us really interested in the mechanisms responsible for this variation.

But you know there are also bigger-scale things going on. I'm just going to take a little biology detour right here. All the monarchs from the whole northeastern part of the United States and southeastern Canada, migrate to Mexico in the fall. This is the simplified picture, there are a few that don't do exactly that. But most of them migrate to Mexico in the fall, they stay there all winter, and then they come back in the spring and they move north – they kind of funnel into Texas and then spread out, moving a little ways north, up to Oklahoma or even Kansas, and then move east – you have this wave of monarchs that spread a little ways north and all the way east to the Atlantic Ocean. There's a generation of breeding that goes on in the southeastern quarter of the United States, and then offspring that are laid by that generation form the next generation that moves north. So it's their offspring that re-colonize the north, moving north in a wave from that whole southern breeding range.

We were really interested in how survival varied in the first and second generations, if it changed over the course of a season, since we were seeing really different patterns in the different sites that we were monitoring. We thought that we probably weren't getting the whole picture, because just within our two or three sites there was so much variation. So we thought it would be really interesting to compare mortality in different generations, and along the migratory pathway, and also in different kinds of habitats.

We were also interested in how densities varied from region to region. For example, monarchs that reach upstate New York have to go around mountains, and their parents had to travel farther than those whose offspring went to the Upper Midwest. In most years densities are much lower in the northeast than they are in the Midwest, but some years we have bad weather in the Midwest, and the northeast becomes more important in terms of the entire population. We were really interested in these kinds of spatial patterns, so our questions about different habitat types needed to be overlain on different migratory dynamics. And we really did need the whole picture to understand what was going on.

So, from the very beginning we were interested in basic questions about monarch distribution and abundance, and in the factors that might affect them. Our protocols involve people searching milkweed plants for monarchs, and keeping track of the number of plants they look at and the number of monarchs they see. They also keep track of characteristics of their monitoring site, including the density of milkweed there. Michelle was also interested from the very beginning in the plants that female monarchs choose to lay their eggs on. So we developed a protocol that involved the volunteers in collecting data on what we call occupied plants, plants with monarch eggs or larvae on them, and also on random plants. And that was something that we got the answer to early on. It's not a trend question, it's just what do female monarchs prefer? And so because this was a time consuming question to analyze, and a time consuming protocol to implement, we actually took that protocol out. We stopped having people do it. But we got complaints from volunteers – they said that that's what they really learn the most from, really taking a detailed look at the milkweed plants. So we put it back in even though we know the answer to that question. That process was interesting, and really illustrated the educational value people perceived from collecting the data.

We've now added a couple protocols. Basically our project has one protocol that everybody does, that's count milkweed plants and the number of eggs and larvae. Everything else is optional. Sometimes we work with individual volunteers to develop optional activities, for example, our data on monarch density are just monarchs per plant. People go out and look at a hundred plants and they see five monarchs, and we get that monarch per plant density is five percent. But that doesn't tell us if all five of those monarchs were on the same plant or if they were on five different plants, so we're actually adding a protocol to let volunteers keep track of the number of monarchs on each occupied plant. Last year we piloted the eggs per occupied plant protocol. We always do everything new ourselves first, on the three sites that our lab monitors. Because our project is probably more complicated than most citizen science projects, this is important. The record keeping is more complicated for the volunteers, but it's working, and we're able to determine if those five monarchs are all on one plant, on five different plants, three on one, and all the possible permutations. This will allow us to answer some really interesting questions about female choice of plants, for example whether they avoid laying eggs on plants that are already occupied by a monarch. From a disease spread perspective it's really interesting to look at how monarchs are distributed through the environment, and that's an example of another question that we're interested in that can be better answered after this protocol change. We might do it for a few years, and kind of see how that happens. So that's happened a couple times throughout the project, that we've changed things to answer a question that either we or a volunteer came up with.

Probably the biggest thing that we have problems with is randomness. People are supposed to choose plants to look at randomly, they're not supposed to just look at the really great looking milkweed plants. We had to teach some basic methodological issues, like, what does random mean? What's a transect? When you look at the condition of thirty random plants in your field, how do you pick random plants? And that's been a constant struggle. If we were going to go out and do that we'd use a random number generator, but this would be complicated for volunteers. Some of our volunteers do that, but we have come up with other options like, flip a coin, or toss a pen into the air and see which way it points when it lands down. So we do struggle with the whole issue of randomness. If they have a big field, and they're estimating the density of milkweed plants in that field, we struggled hard to come up with ways to estimate density in a way that we could explain easily. Picking a random transect and counting the plants in the random transect really bothers people, because they feel like they're missing patches of milkweed. So that's something we've constantly struggled with, is sort of the scientific complexity of the method. But I think in most cases we've come up with pretty good ways to explain them.

The first NSF grant we had that was centered on MLMP was a teacher enhancement grant, from 1998-2000, way back in the days when these grants involved both teachers and their students. For three years groups of ten teachers with two kids each came to learn about monarchs and monarch monitoring. All of them were involved in the MLMP methods, so as the project was evolving we were actually working with teachers and students who were doing it. We also had a $3000 grant from the Xerces Society that supported workshops at nature centers around the country. Michelle went out and trained people to do the project, then watched them do it during the training. And I think the most important thing was that we were always doing the protocols here, training undergraduates[5], and eventually new graduate students every year. We also have high school students in our lab, so, we watched a lot of people learning to do the project, and saw the mistakes they made, saw what interested them, saw what questions they had, and that really helped as we were developing the protocols and the kind of cheerleading techniques that keep people going.

After we did the work with the teachers and the students, we got an ISE-NSF grant, and all of sudden we had some money to focus on developing this project for the first time. This allowed us to work on the project itself, not just specific aspects of the project that would be interesting to teachers. So, from 2001-2005 we did a lot of in-person training. We could do workshops all over the country. We worked with partner nature centers and museums, who would invite people from their region to come to two-day workshop to learn about the MLMP in a train the trainer model. We would teach people about the protocols and findings of the MLMP, and that allowed us to develop a network. Participants would go back to their nature centers and do trainings, and a lot of those people are still really heavily involved with the project.

Since this hands-on training from 2001-2005, we haven't had external grant funding that's been specifically dedicated to this project, so now almost all of our training is online. We still have the original network of trainers plus people who have been doing the project for a long time who are listed as contact for people in their areas who want to learn how to do this. When we ask them if they're willing to help people, most of them say yes, so we have resources for people to contact, and ask questions. If anyone is near our lab we'll just say, come and do it with us for a couple of weeks – if you look at a map of our volunteers, there's a huge cluster of them right around here. Or we'll do local trainings. We don't have the funding to travel all over the country and do trainings, but we can certainly talk to local groups. So, now it's kind of a combination of a train-the-trainer network that we put in place, online training, and people coming to us.

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[5] See: Oberhauser, K. and G. LeBuhn 2012. Insects and plants: engaging undergraduates in authentic research through citizen science. *Frontiers in Ecology and the Environment* **10**: 318–320. http://dx.doi.org/10.1890/110274

Now we're focusing on something that grew out of the blend between the citizen science project and all the other work that we do with teachers here. We run classes for forty to eighty teachers every summer, and a lot of these teachers do this monitoring project. At the very end of our last NSF grant that was focused on the MLMP, we had some funding left over that we used to bring a lot of the teachers or naturalists who were doing this project with kids to a meeting with monarch scientists in California. We worked with all those kids who came to this meeting to make a poster. Most of this we did long distance, because a lot of them were coming from other states, Michigan, Indiana, Ohio, and Wisconsin. And a lot of those teachers had done data analyses that were different than the exact MLMP protocol. So, I kind of looked at that and thought, "woah, they are really taking this the next step – they're doing their own inquiry." That experience was the impetus for our new Driven to Discover grant. The goal of the new project is to support them, kind of help them to take that next step.

I've been thinking a lot lately about how all of these projects are connected. I have this Citizen Science project, the Monarch Larva Monitoring Project, which, at least originally, was explicitly addressed toward adults. When we first developed the MLMP, it was really to answer research questions. So we developed the protocols and the materials with an adult audience in mind. In the beginning all of the work that we do with teachers was quite separate, I really didn't make the strong connections between MLMP and the K-12 work, just because I thought, well, maybe teachers will want to do this on their own, but it probably wouldn't be something that they would engage youth in.

And then we found what really happened with the MLMP is that we get a fairly large percentage of people that do this project with children, from year to year ranging from a third to a little bit over a half of all of our volunteers, So their goals in taking part in the project are quite different from adults who go out on their own. We find adults who do this on their own to do this are going out, a lot of them, just kind of to enjoy nature, they just love poking around the same part of land every week. They like looking at the same plants, and seeing the phenology happen at their site. Getting to know all of the insects that come to the site, so they're very self-directed, and I think most of them do it because it's just a lot of fun. They're learning a lot, and they feel like they're contributing something, but it's just very relaxing and enjoyable.

But then there's this group of about half of our volunteers that are doing it with children, and their motivation is different. They're still enjoying it, but they're very focused on what the kids they're monitoring with are learning. They're very interested in teaching science. But there are three categories of people who monitor with kids. There are parents, and they're doing it because they want to teach their kids about science, they want their kids to enjoy nature, they want their kids to be involved in sort of conservation or environmental actions. Then there are teachers who have very explicit learning goals – they have science standards in mind and inquiry, and so they're interested in the research aspects of the program. And then we have a big other category of people who are in different kinds of informal science education -- people at nature centers who use it as programming, and they might have a group of kids who come for a week, or they might have a couple kids like high school interns who come once or twice a week. There are the other kinds of informal science people, like Girl Scout leaders, 4H leaders or Boy Scout leaders.

So we have these three categories, and because they're really focused on what the kids are learning, we started developing science education aspects of the program more explicitly. I give many courses for teachers, for the last 17 years I've given 3-credit courses for teachers every summer, and I've been kind of involved in the whole evolution of inquiry-based science education at the state level and at the national level. So it just kind of clicked for me that engaging in citizen science is so directly connected with inquiry learning, because what people are doing is they're going out and making really detailed observations of phenomena. And they just naturally come up with questions. So what we're trying to do with this program is to give them the tools to answer the questions that they naturally come up with.

The inquiry emphasis is probably because it's such a focus in the work that I do with teachers, and I know it's so important to the national and our state science standards. It's interesting, I just did a workshop for graduate students who are interested in outreach to K-12, and we sat down and looked really carefully at science standards, and they noted what's so apparent in the science standards – there are content standards, and process standards. And the content standards are kind of difficult, because they're so specific and there aren't standards to, let's say, learn to recognize birds, or understand the life-cycle of a monarch butterfly, and understand predators of a monarch butterfly, and understand the relationship between milkweed plants and monarchs. We can certainly get at things like, there are a lot of animals that eat plants, and there are predators in the world, and there's a lot of diversity – there are many bird species. So there are some content standards that we could kind of get at with the citizen science project, but it so much better lends itself to the process of science rather than the content of science.

But if you look at the process standards, they're all about inquiry, and what we do addresses them perfectly. So it just seemed that we could make a better contribution to science education by focusing on those process standards, instead of the narrow content standards. And it's not just K-12 teachers who are interested in this, though we do have a fair number of K-12 teachers in our audience, who understand these standards, and know they have to address them. But ISE groups, people who are working at nature centers, maybe not the Girl Scout leaders and the 4H leaders, because they really don't need to be addressing standards, but certainly a lot of our ISE audience is interested in addressing standards, so it really was connected very directly to what's going on with science education standards.

It's been very interesting working with the adults. In a way, this is a train-the-trainer program because we're working most directly with the adult leaders, and giving them the tools to actually guide the youth they work with through the whole inquiry process. We're going beyond helping people answer questions that have already been set up, but instead trying to help them use their observations to answer other questions, using them to come up with their own questions. This happens naturally, but we're finding that it's actually quite difficult to – except for teachers, it's very easy for teachers to do this – but it's difficult for other audiences to mentor these youth. So we're struggling with this. But our motivation was to really help them use the observations the youth made to foster this process of inquiry, which isn't completely easy, but in some cases it's succeeding really well.

So, for Driven to Discover we have three different models that promote deeper engagement in inquiry by our volunteers. One thing people could do is just analyze their own data. Really, as part of our basic protocol they don't do their own analyses, they enter the data and the data are displayed graphically, but we don't really support them in analyzing the data they collect. So, that's one model, is they'll collect data using our protocols and they'll analyze their own data.

A second model would be, they collect data and they want to compare their data and somebody else's data. There are data that can't be accessed online except by the person who put them in, so we'll support them by providing other data, so they can do, for example, state-to-state comparisons, or region-to-region comparisons. But their questions may be similar to the kinds of questions that we were asking about the data. And then a third model is that they are actually using the observations they make as part of the citizen science protocol as a springboard to asking their own questions that might require additional kinds of data collection.

In the project that we did with the kids we brought to California, all three of those models happened. One group compared their own data from one year to another. Another group, from a little town in New London, Minnesota noticed that there was also a monitoring site in New London, Wisconsin, and we helped them get those data to compare monarch densities. And then, some of the students asked completely different questions. For example, while she was monitoring one girl noticed these weevils that are really common on milkweed plants. And so even though our project has nothing to do with weevils, she did a whole study of the distribution of weevils and their effect on the milkweed plants. So we've kind of seen all these things happen before, and in the Driven to Discover project we're just trying to institutionalize a way to help people do these things on their own. We train adult leaders to work with youth on a citizen science project focused on either birds or monarchs, and over the course of a summer they use a curriculum that we've developed and have a scientist visit their group for 3 or 4 monitoring sessions.

We're starting our second year of the Driven to Discover project, and we have eleven groups this year. We decided to keep half of them from last year, because we were really interested in how they changed with another year of involvement in the project. Some of those are the same adult leaders and the same children, and some of them are the same adult leaders with different groups of children. We have two levels of engagement with the repeats from last year. Some of them just did really well on it last year and we felt like they didn't really need our help that much, so we're acting as sort of consulting scientists with them. But we're engaging more intensively with others, that we felt would benefit from another year of more intensive engagement.

What we're doing is trying to really understand the process by which this whole inquiry thing can happen, the kinds of mentoring, the kinds of activities that you need to do with the youth. We're working with groups led by teachers and informal science education groups, including 4-H groups, a Boy Scout group, a Girl Scout group, and a group that we're calling a 4-H group but it's really a parent who has pulled together a bunch of kids so it's kind of blurring this line between parents and other leaders– she has two of her own kids, but then several other kids in the group as well. All of these groups are formed explicitly around the goal of engaging in the Citizen Science project. And they're half doing eBird, and half doing MLMP. Parents are more of a moving target so we haven't targeted them explicitly, but we're hoping that the materials we develop will be useful for parents as well.

The goal of Driven to Discover was to develop something that can be used by other citizen science programs without necessarily having this intense scientist engagement. And one of the things that I think we're learning is, that may not be very realistic. It will be interesting to see, once we have all of the data together and we really see what the groups are doing, but we're learning that it's not that easy to train adult leaders to really be good inquiry coaches, especially adult leaders who aren't teachers. So we've deliberately chosen some teachers who really are steeped in teaching kids about science, or at least teaching kids. And then we have a lot of leaders who are not, who have all different kinds of jobs, and really don't have that kind of experience. And it'll be interesting in other years of the project to see if this is something that can be done in a training session without our continued involvement after the training. We did try to teach everything they needed to know in a one and a half day training session, we continued to engage with them over the course of the whole summer. I'm not sure how possible it would be to do in a one and a half day training without continued engagement—if this will really be enough in their blood to really mentor the kids on projects.

Just this morning at quarter to nine I was sitting at my desk and one of the adult leaders called and she said, “I’m outside your building and I have Estelle[6] with me here, and she really wants to spend a day in your lab.” Completely out of the blue. Estelle is a 7th grade girl that just is really taken with monarchs, so she hung out in my lab until 11 o’clock this morning and helped the undergrads feed caterpillars. So she’s decided she wants to be a butterfly biologist when she grows up. She is an interesting one because she worked with a group last year, and now she’s kind of helping with another group. So it’s interesting to see the same kids involved in it year after year, you can really see that you’re kind of making a difference in lives. And they’re doing good research projects, we’ve really learned about the capabilities of these different ages of kids, so we’ve had to maybe – not lower our expectations, but just be a little bit more realistic about what they can do. So I think that’s going to really help this year.

But I think we’ve also learned that just the engagement in the citizen science projects themselves is huge for them, just entering data online, collecting data in a systematic fashion, learning the biology of the organism…. So this girl that I was telling you about, Estelle, last year worked on a bird project. I was talking to her while I was out with her group last week, and I said, “What birds did you know before you started this?” and she didn’t know any. She didn’t even know robins. And then she listed off all of the bird species that she learned, and she listed probably ten different species, and she knew their biology, she knew where you could find these birds, she knew a little bit about their nests, because they had found a couple nests. So I think in some ways just learning this biology might be such a huge step for some of these kids, because they’ve never really learned natural history, you know? You don’t learn about bird species in school, or monarch metamorphosis. So I think that’s another thing we’re learning in this project, that we should be really excited about the basic biology that they’re learning, and that it might not be realistic to expect them to do big inquiry-based studies based on their observations. Although they certainly are doing interesting inquiry-based studies, but maybe not the kind of studies we expected.

And I think that really is such an important thing about citizen science. I think that just being involved with the citizen science protocols, and the natural history on whatever the project is, whether they’re collecting data on weather or organisms, they’re learning a lot of things that they don’t learn elsewhere, and I think that’s something we really all need to recognize. The youth and the adults are both learning. The leader of this group didn’t know any bird species either. I mean, she must have known robins, but she was not familiar with kinds of birds that were in her yard. She was very excited about telling me about cedar waxwings, asking me, “do you know about cedar waxwings, and how beautiful they are?” So it was neat.

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[6] A pseudonym.

Even just for MLMP in general, I think the education from the natural history perspective is really important. Another thing that I think is really important is the social aspect of working together on a citizen science project, and the adults working with kids. That's one of the other things that I've really noticed and think is a huge value of this project, is it's a social opportunity for people. A lot of MLMP volunteers do it in groups, like nature centers that have programs where they have a group of volunteers who all come at the same time on the same day – they work out schedules, they have teams that collect the data together, they often do parent-child groups. We work with a lot of nature centers and a lot of naturalists who run this program at the nature centers really do use it in social ways. So there's the education, the conservation, and then this providing a way for people to get to know others with similar interests. To work with kids, I think that's another neat thing that happens with a lot of these projects.

I think it was always clear to us that the volunteers involved in collecting the data were learning a ton while they were doing it. And because all of my students have always been really involved with the outreach work, we had all this stuff going on in our lab that was centered on science education. As we saw what the volunteers were learning, the kinds of questions they were asking, it was clear that this had a lot more than just the data collection and the scientific value to us, that it was an educational project for the people involved as well. So, you know, while they were collecting really important data to Michelle's thesis, and then continuing through the decades, they were also learning a lot. So really, from the beginning, we were focused on both the science and the educational outcomes of the project. And now we're really focusing on the conservation aspects of the project, which kind of is connected with me moving into a Conservation Biology program at the University of Minnesota, and really thinking more about that piece of the project as well.

I got a PhD in 1989 and actually didn't get a tenure track position until about 2003. I was a research associate, originally affiliated with an ecology department that was not as open to non-traditional kinds of work, much more focused on, you know, straight research. The college and department that I joined[7] has a much broader focus that includes more emphasis on community outreach and community education. A third of my appointment is now Extension, so in my current appointment I can count all of the outreach things that I do, including the citizen science project, as an official part of my job. I'm not sure what was the chicken and what was the egg here, but certainly my position now because of the Extension appointment and because of the more community focused mission of my new department and college, makes it all fit together a little more seamlessly. But it's hard to say if the position made it easier for me to do all of this, or if all of this is driving success in my academic life, I think it's all kind of tied together in a way that's hard to say what's driving what.

[7] Natural Resources, now called the College of Food, Agriculture, and Natural Resources Sciences.

I turned in my whole package in the Fall of 2007, and was tenured in 2008. I think in a lot of cases the tenure process is a real penny-counting thing. I'm not sure that I can directly say how MLMP was received as part of my tenure, because the tenure packet is such a huge thing. But here, and I really don't know how it is at other universities, we have to put together a tenure package that explicitly addresses research, teaching, and outreach. And because I have a thirty percent Extension appointment, the outreach is very important. Part of the mission of a land grant university is the work that we do taking things that happen at the university out to the people of the state of Minnesota. So I'm quite sure I put everything that I did with the MLMP in the outreach part. In fact, I remember saying that this project really straddles research and outreach, because it has explicit outreach components, but it's also very relevant to my research. So it was something that I could kind of double count, because it's resulted in several publications, and it's also something that I can point to that is so explicitly outreach. So I probably talked about it in both sections of my dossier. I don't think that there were any eyebrows raised that I was spending all this time on outreach, just because it's a part of everyone's mission, and especially people who have Extension appointments.

And I've gotten several publications using data from the MLMP, including publications with volunteers as coauthors. So I think in that respect it's probably been positive, because it's a great source of really exciting data. In many ways, the project has really kind of given me a research focus. And it's also been really useful because of a new emphasis on conservation. I have data that can help tell us about trends in monarch populations.

One of the things that I'm doing right now, which is really great for my career, is that I'm part of a group of people that are trying to create kind of a meta-data set that we're calling MonarchNet. It's an organization that's bringing in all these different monarch databases, and we got a grant from NCEAS, the National Center for Ecological Analysis and Synthesis, to set up a data structure for all of these different data sets. We're actually kind of modeling this after the bird world, the Avian Knowledge Network, bringing together all these different kinds of databases on birds. There are lots of different citizen monitoring programs that address monarchs … there's Monarch Watch, there's Journey North, the Monarch Larva Monitoring Project, the North American Butterfly Association, several butterfly monitoring networks that go out on a weekly basis and count all the butterflies they see. I'm probably missing some, but there are many citizen science monitoring projects, and other long term monitoring projects that have data on monarchs.

We just had our third meeting, and that was really exciting. We brought people like Elizabeth Howard from Journey North[8] – who has an amazing treasure-trove of monarch migration data – and people from the over-wintering sites in Mexico that are collecting data on the population there. And then we used data from some citizen monitoring programs from the west coast population, and then some of the butterfly monitoring programs, like the North American Butterfly Association, and these butterfly monitoring networks in Illinois, Indiana, Ohio, and Florida, and a couple other databases that people have been accumulating that we learned about. So we had the people that worked with all of these databases, as well as people that were experts in pulling together datasets that involved overlaying weather patterns and population dynamic patterns, and looking at long-term temporal changes, really trying to see how within a year how one phase of the migratory cycle affects another phase, and how dynamics in one year affect dynamics in the next year. We're still working on all of the papers, but it has been really interesting to pull together all of these different monitoring datasets, and to think about how we can improve the way that they complement each other, and how we can make sure that the data are more useful, for example looking at the fields of data that are collected, and, "Oh, if we had just asked this, this would have been a lot more useful." So really using the analysis to inform the further development of the program. It's been really exciting to combine improving our understanding of monarch biology with improving the programs themselves.

One paper that I'm working on now, as part of this collaboration, is looking at monarch breeding in the wintertime. I told you they migrate to Mexico and they don't breed in Mexico, and they come back in the spring and breed. But some monarchs stay in the United States, and some of them are breeding, and some of them aren't breeding. I have to get into a little more biology here. If they're not breeding, they can live a lot longer—they're in the state that insects go into called diapause. Which is basically like hibernating, but they can be moving around. It's basically putting the metamorphic development on hold. For example, insects that overwinter in Ithaca, will overwinter as either an egg, a larva, a pupa, or an adult, and they're staying alive and not freezing, they're staying alive through the whole winter, so that's called diapause. And monarchs diapause as adults, who can fly but they're not reproductive. So anyway, we have monarchs that are in diapause, we know that there are monarchs in diapause in the United States, and there are monarchs that are breeding in the winter in the United States. So we're pulling together data from the Journey North citizen science program, the Monarch Larva Monitoring Project, and then anecdotal reports from people who know that I'm interested in monarchs, and that Elizabeth Howard is interested in monarchs and who send us little snippets of emails that we've just both been saving over all these years. They'll say, "we saw monarch caterpillars in our yard on January 15th in

[8] Journey North, http://www.learner.org/jnorth/, is a youth-focused citizen science project tracking aspects of seasonal change. The Monarch Butterfly research was one of the earliest components of Journey North, engaging schools across North America in sharing observations of migrating monarchs.

Houston Texas." We've pulled together those kinds of observations, plus official reports from our websites, and are writing a paper on monarch overwintering in the United States, and then we're relating that to disease dynamics from this other citizen science program called Project Monarch Health. So we're pulling together data from all of these different projects and saying something new about monarchs[9].

We're also working on documenting overall patterns and numbers and relating them to climate. For example, we have this wonderful dataset from Ohio where people go out every week and monitor every single butterfly that they see. So we have really good data using the same methods and the same transects, and we can relate patterns to weather. We're working with people that really know how to work with weather data, and relating numbers in the breeding stage of the annual cycle to numbers in the migratory and wintering stages of the annual cycle[10].

I think one thing that happens is that people who are involved in these citizen science programs are used to cooperating and collaborating. It's the other people that we've pulled in to help us with the weather dynamics and climate change are very surprised at how well we all work together and share our data. But I think that comes from the fact that we collect data in unusual ways, we kind of feel that the data kind of belong to the public.

We're finding that there's some overlap in the kinds of data we collect. Which is fine, because different people know about different programs. But we're looking at that and thinking, well, if we are collecting the same data, how can we ensure that people aren't reporting the same data to both of us, and how will we know how to avoid double-counting of the same data? We've looked at some programs that have comments fields instead of data fields, so we had to basically sort through a lot of online comments, and we could really learn from each other by looking at the way that other people collected the data; we could improve the reporting methods that made the data more usable. It certainly really helped to sit in a room with people and work through some of the same questions, and think "well, maybe this would work a little better," and at the same time that we were together talking about protocols we were using the data. So I think it was a nice loop of conversation that improved the ease with which people could report the data, the usefulness of the data, and the sort of complementarity of the data in the different programs.

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[9] See Rebecca A. Bartel, Karen S. Oberhauser, Jacobus C. de Roode, and Sonia M. Altizer 2011. Monarch butterfly migration and parasite transmission in eastern North America. Ecology 92:342–351. http://dx.doi.org/10.1890/10-0489.1

[10] Now published: Zipkin, E. F., L. Ries, R. Reeves, J. Regetz, and K.S. Oberhauser. 2012. Tracking climate impacts on the migratory monarch butterfly. Global Change Biology 18:3039-3049. doi: 10.1111/j.1365-2486.2012.02751.x

So that's been really positive, to think about how all of these different programs that monitor monarchs could fit together and how we could learn more about the populations. That's exciting for our volunteers, too, because a lot of them are involved in more than one project. From an educational perspective for the volunteers, they're seeing how we can use all of these different data sets; it's hugely important from a scientific perspective; and from a conservation perspective as well, because we can really finally try to get a handle on what's going on with monarch populations.

One of our MLMP protocols focuses on rates of parasitism. If you collect the monarch caterpillars from the wild, some of them are going to be parasitized by this parasitoid called a tachinid fly. So, instead of getting a monarch you get some flies out of your monarch caterpillar. We had three volunteers who were really interested in this, and they collected hundreds of larvae that they raised in their home to see if they were parasitized by the fly, and they collected them at different stages and at different times of the year. A woman in Michigan said, "you know, this really isn't part of your protocol but I've been collecting these for the last couple years, and there are really cool patterns that vary a lot from year to year." So then we did an analysis of her data and data from another woman in Wisconsin and a man in North Carolina who were also collecting a lot of monarchs. We looked at their data in great detail, because they were collecting extra data, and we also took all of the data from all the other volunteers, and did this analysis of levels of parasitism. And it really just grew out of this woman saying, "wow this is really interesting, and I wish that there was a place on your website where I could put all this information that I'm collecting" so, that led to a publication on monarchs and tachinid flies[11].

When we first started the MLMP, we actually had very explicit directions that volunteers were not to collect any monarchs from their sites. Since we were interested in measuring survival, if they were collecting some eggs we really wouldn't be able to calculate survival – I mean, *natural* survival, because there's naturally very high mortality in the egg and larval stage. But our volunteers were faithfully following the protocol, and they'd go out one week and see thirty eggs, and then the next week they'd go out and see five caterpillars. So they knew that most of those eggs died, and they were doing this project because they really loved monarchs. Some of them were very stressed, because they felt like they're looking at all these eggs, and they know most of them are going to die before they even come back and look at them again in a week, so we had people quitting because they didn't want to watch that happen. So we changed the protocol, because we couldn't use data from some sites for survival analyses if they were collecting the eggs. So then what we did is we said, "ok, you can collect eggs, but you have to tell us that you're doing that." We only use their egg numbers, not their larvae numbers. It's not that

[11] Oberhauser, K., I. Gebhard, C. Cameron, S. Oberhauser. 2007. Parisitism of Monarch Butterflies (Danaus plexippus) by Lespesia archippivora (Diptera: Tachinidae). American Midland Naturalist 157:312-328.

high a percentage, maybe 10% of our volunteers, but we literally have to throw out all of their larval data.

But as long as they just go out and look at eggs once a week, even if they collect all those eggs, all those eggs would be hatched the following week, so we're not having any effect on egg numbers by collecting eggs. So on their site information form, we ask them, "do you collect any of the monarchs at your site?" And we say, "it's ok if you do, just tell us you do, and then we use your data differently." So we've kind of had to respond to their unwillingness to observe all of this natural monarch mortality. And another thing we've changed is request that they put any flies that emerge back on their site, because we didn't want to change the density of flies on their sites. One guy wrote and he said, "I can't in good conscience put those flies back on the site." So, we have to understand that when we're analyzing data from his site.

You know, sometimes there's kind of a fine line between research and conservation. We can do research that might help us understand how better to protect monarchs, and if we know natural mortality levels, we can understand mortality levels from human-caused things. But sometimes when you're studying something you see things that you could do from a conservation perspective that could mess up the science of it. And I think that's often a tension. I think that happens to a lot of biologists, that they go from being straight research biologists to conservationists who have resolved that tension by doing the things that they can do that will preserve the species and the habitats that they study, that might not fit in with experiments that they used to be doing.

My work has certainly become more focused on conservation. The winter breeding paper that I'm writing has a strong climate change connection. I'm also really interested in impacts of pesticides on monarchs, both herbicides and insecticides, and interested in effects of changing habitat, like increased suburbanization of habitat and how we can get people to include a little more biodiversity in their yards. So yeah, it's definitely something that I've changed, like I don't study paternal investment anymore. And I really do think that the connections that the citizen science projects are making for people increase their own connections and their own conservation behaviors. So I feel like, it's kind of an education to engage people in these projects, and definitely I have conservation motives there.

We've seen that our volunteers develop these very long-term and intimate relationships, these very close connections with a piece of land, because the way that our project is set up, it really is explicitly directed to a single place. And people really start to understand and feel connected to this place. Especially if they're monitoring their own land – or even if they're monitoring land that's not theirs, like at a nature center or a state park or a neighbor's land – people really care about what happens to it, and they just naturally learn through their observations the kinds of things that promote biodiversity, and promote the use of the land by pollinators, both monarchs and other pollinators, and other organisms. So they take conservation actions to directly impact the land that they monitor. So we've started to try to kind of capture the things that they're doing on these monitoring sites. They become strong advocates, not only for their own land – we've had cases of people monitoring a vacant lot that was going to get turned into a parking lot – they are very motivated to take action to protect that piece of land. So there's this kind of direct conservation action that they take.

They also become strong advocates at political levels. They'll advocate about development in general and conservation in general. They talk to newspaper reporters because a lot of people are really interested in monarchs, they get a lot of publicity and we have stacks and stacks of newspaper articles that are the results of interviews in local papers by our volunteers[12]. And they almost always talk to the reporters about conservation, what they're doing to help monarchs, the kind of habitat that's good for monarchs, so they develop this broader advocacy role. And they really teach people through both this media attention, or they do the project with children, or they talk to people who walk by while they're monitoring and ask them what they're doing. In these personal interactions with people, they focus not only on the biology, but on conservation. They really are doing a lot to conserve both the land, the actual land that they monitor, and land in general for monarchs and plants and other pollinators, and to educate people, especially children. It's been very interesting to try to track these behaviors that people have. Certainly it's difficult to separate cause and effect here; the people that choose to engage in something like this that's fairly time-consuming and requires that they have access to a piece of land that they can monitor, probably are already motivated to do conservation things, but a lot of them say that at least some of the actions they're doing are directly a result of their engagement in MLMP.

We've thought of things that we could do to support their conservation work, and haven't really had the resources yet to do that, except just on a small scale. People write to us and ask things like, "can you write a letter to this city council that says this land is really important for monarchs and so you shouldn't build a parking lot or a big box store?" We will sometimes write letters saying, "this is a monitoring site, it's really valuable to us because this person has been recording data at this site for x number of years, so it's a valuable long-term monitoring site." Or, some people are concerned that wind turbines are hurting bats and birds, or hurting butterflies, especially monarchs when they're migrating. So people want me to write letters about stopping a wind turbine from being placed in their area that might have monarchs migrating through.

We have a lot of ideas for how we could more explicitly support conservation actions, and so far we haven't really done this, besides these kind of small-scale things with individuals. But certainly we could put together materials that they could use for this,

[12] For an archive of online articles, see: http://www.mlmp.org/news.aspx

there are a lot of things we've thought of that we could do. I think it would be a great thing for citizen science to do in general, to kind of develop some kind of package that we could give to people to help them develop conservation projects, although I guess all of our programs are so different that they'd have to be really tailored to individual programs to be meaningful.

One of the things that we've really talked a lot about doing is developing a good land assessment tool, or habitat assessment tool, that would help people quickly gauge the value of a habitat to monarchs, and think about things that are missing in habitats. This would be a tool that could be used both by professional land managers, but also individual people, sort of helpful hints for making your land better habitat for monarchs. And that would be something that our volunteers themselves could use on their own land, but they could also share with other people. We've talked about putting together sort of a news release packet, something that people could use. And certainly we have a lot of tools that are part of the project in general that are physical things that they can share with people. But they're more focused on the biology of monarchs and helping people recognize different stages of monarchs and different insects that they might see, and they don't really have an explicit conservation focus. So that's another thing we've talked about, is developing written materials that they could share with other people. We've talked about having little workshops, so going to places where we have clusters of monitors and supporting them in teaching people about conservation. So we've talked about doing sort of land habitat management workshops in some of the places where we have concentrations of volunteers.

Something else that just kind of evolved out of the program, partly reflecting my own professional evolution, is changing from a scientist asking very basic questions about ecology and organisms to moving into questions that have a much stronger conservation focus. So I think that I've become more open during my own professional trajectory to seeing the conservation connections to almost everything that I do.

Julia Parrish
University of Washington

Connecting with people and place

Julia launched COASST, the Coastal Observation and Seabird Survey Team, in the late 1990s. Since interviewing Julia I have had the chance to collaborate with her on several group research and writing projects, and have come to appreciate her pragmatism about citizen science. I used to refer to citizen science as a source of "otherwise inaccessible *data," but Julia has reminded me that in many cases other means are possible and possibly even preferable – just not affordable (I now use the term "unfeasible"). I have also heard Julia caution numerous times against being "Pollyanna-ish" regarding citizen science outcomes, referencing the title character of Eleanor Porter's classic novel who is known for boundless (if uncritical) optimism. Julia is now also applying that pragmatism to NSF-funded investigations of participant learning.*

I'm a seabird biologist, and I work on a seabird colony on Tatoosh Island, located about half a mile off the northwest tip of the Olympic peninsula, which is the peninsula that frames the northwest corner of Washington State. I started COASST[1] because after quite a few years of working on a single seabird colony we knew a lot about the birds that nested there. We knew when they would come and when they would leave, and how many there were, and how well they did from one year to the next in terms of producing chicks, and what they ate, and who ate them, and on and on and on and on. That was really gratifying at that local, individual colony, individual researcher level. But it was also frustrating at a larger level, because we didn't know whether what was happening at that colony was typical of what was happening on our part of the coast, or even on the west coast in general, or whether it was idiosyncratic to that one place. For a while what we tried to do was work on several colonies, but that takes a huge amount of effort and also a huge amount of funding, and it was just not sustainable. And so I was looking for another way to find out information about the main bird that we study, the Common Murre, and one of the things that I noticed was that dead murres washed up on the beaches of the island that I was working on. And I thought, "hmmm, I wonder if this is just a usual pattern?" So I did a little reading about each bird and I hired somebody to actually walk beaches in Ocean Shores on the coast of Washington where the beaches are big and sandy and you can actually drive on them, to collect some initial information to see whether my thoughts about birds washing up on more than just the island that I was working on were right. And they were, and so that's how we got our start.

[1] Coastal Observation and Seabird Survey Team, http://depts.washington.edu/coasst/

COASST is quite literally an organization where we teach, I usually say real people – so, non-scientists, anybody and everybody – to walk beaches, usually *their* beach, a beach that they have a particular affinity for, they have a connection to. And they're looking for dead birds, birds that have washed up on the tide, and they're identifying them, using materials that we give them and training that we've given them, and then they're turning that information back to us. They're doing that on a monthly basis. And that process, at the individual level, is interesting and can be quite rewarding for an individual, because they're doing something that's new, they're finding out something about their backyard, and about birds, and they're doing it in a scientific way, so they can see whether they're right or they're wrong, and they can improve. And because there are lots of people that are doing that, we can put together larger patterns of occurrence, or absence, or some untoward event, and then we can turn around and tell that story back to the participants and also anybody else, in a bunch of venues – written ones, and things on the web, and things in the scientific literature.

Tatoosh Island, where I study a single seabird colony, is literally the northwestern most point in the continental US. And it's obviously a little bit of mainland that got eroded away so a little channel has been cut. And it's an interesting island in that it has been inhabited for millennia, and that's because the Makah Nation has lived in that part of coastal Washington for – depending on whose dating techniques you believe – at least ten thousand years. And so the island was a summering ground for them, including the place that they launched whaling expeditions from and where they caught halibut and dried halibut on big racks in the intertidal. We, western civilization, conquered them and took over the island in about the 1850s, and built a lighthouse out there, and soon the western population on the island – which is very small, it's only a few hectares – the western population swelled to a maximum of maybe 90 people living there full-time, just crowded in all kinds of buildings.

By that time the "natural environment" had been pretty much…. On the top, the main island is flat and slightly sloping back towards the east, so it's like a butte that's been canted a little bit. All of that was houses and yards, and the precursor of the coastguard rescue service was based out there. And as Washington grew from a territory to a state and the division between state and federal services became more defined and technology increased, as we moved into the 1950s and 60s, the number of people on Tatoosh went down. And eventually, by the early 80s in the Reagan era, we gave the island back to the Makah. And by that time all westerners had moved off the island, maybe because services had been consolidated on the mainland, so there was basically no reason to have the island anymore.

And about that same period of time, maybe the mid-70s, a rocky intertidal ecologist named Bob Paine started to work on the outer coast of Washington on the Makah reservation at sites on the mainland, and he went out to Tatoosh and discovered this amazing, rich intertidal, just crowded, crowded, crowded with animals, with invertebrates, and with algae, because the island is very, very rocky. There's only small beaches there – as an intertidal biologist you have this picture of vertical zonation all around the island. And because it's kind of hard to get to – there are a lot of waves and currents around there, and there's no place to moor your boat – people hardly ever go out there. So he moved his research enterprise out there.

He was a professor in the Zoology Department in the University of Washington, and so when I came to U-Dub in 1990, Bob was working out there and his graduate students worked out there, he basically ran his research pretty much all year round out there. And he is a consummate naturalist, and very familiar with absolutely everything that's alive. He loves the rocky intertidal, that's his passion, but he knows as much about the birds as he does about the plants on the island, and so I had a chance to go out there and start working. Actually, I started to work in the intertidal, but I noticed this really interesting set of behaviors in one of the seabirds, Common Murres. And Bob and I would talk about what was going on and I became really interested in it, and Bob was very much a mentor in encouraging my interest. So I'm a post-doc during this time, and I started to work on the murres. And that's how I got my start on Tatoosh.

The island was really a wonderful place in the time after westerners left, when Bob started his work there, when there were no people living there, just researchers visiting. The seabirds that must have colonized the island at least partially when the Makah were there, and certainly before humans arrived on the continent, came back and took over the island. So although the island is small, it has a pretty rich avifauna, including – I don't know, maybe, I lose count – 13 or so seabird species including night active and day active ones, and burrowing ones, and surface ones, and even ones that try and nest in trees, like cormorants. And so it's a really great place to work as a seabird biologist. At the time that I started work there, I wasn't a seabird biologist. In fact, I had worked before that mainly on fish. But the thing that the murres were doing that was really interesting to me was living in a really, really dense group, with birds nesting side by side – kind of like a school of fish which is what I had spent a lot of time working on – and then reacting to predators in particular ways as a group. The predators there are bald eagles and peregrine falcons. And that's kind of like the predator-prey work that I had done with schools of fish and big hungry mouths like tuna or swordfish or groupers. And so I was drawing some analogies between what's going on with schools of fish, and what's going on with groups of birds, and that's why I started to work on murres.

That work for me continued for 20 years. Basically, I worked out there every summer – eventually with my graduate students and post-docs and technicians on the seabirds and mainly on murres, although we did a lot of work on other species as well. And one of the things that occurred to me after about maybe ten years of working out there was, wow, we know a lot about what's going on with this colony, we know a super lot about what's going on with the murres here and how they're interacting with their predators and their space competitors and how they're changing the habitat and the habitat is restricting them and the timing of breeding and what they're eating and how well they're doing - on and on and on. We tagged birds so we knew where they were going after the breeding season so we could put together a very complete, very rich picture of that one colony. But the problem was, was that indicative of all of the murres nesting on the west coast, or just the murres nesting on Tatoosh? And the reason that was an interesting question is because the numbers of murres nesting on the outer coast in Washington was plummeting, and had plummeted during the 80's to a low such that, although records were spotty, it appeared that the only stable breeding colony of murres in Washington was Tatoosh. And that led us to think, well gosh, maybe Tatoosh is in fact the odd man out rather than the standard. So although it's great that we have this information, it's so local it's not useful for saying broader things – or, we don't know how it might be useful.

So one thing that I attempted to do was expand my colony-based research operation to the south to colonies in Washington, and to the north to colonies in British Columbia. And that worked for a while, but it was fantastically expensive to try and map three different field-based research operations every summer. And so I stepped back and thought about how to do a plan B, and I noticed that on our little beach in Tatoosh carcasses would occasionally wash in. Now on Tatoosh, things are a little different, just because Peregrines are bombing around at night and running into Rhinoceros Auklets and Cassin's Auklets and basically ripping their heads off and depositing their carcasses on the beach – so you have to sort of take that into account. But even with that we could see these patterns of birds washing in, and definitely murres, and sometimes murre chicks and I thought, "huh, I wonder if I could get a population signal by looking at what came in on beaches?"

I had done enough back work to know that, when they're at sea, definitely during the breeding season but also during the post-breeding season, the murres stay fairly close to shore, within a kilometer or two of shore. So they're not offshore birds, they're not going somewhere way out into the ocean, the way a bird like a Tufted Puffin, which is a relative of the murre here on the west coast, would go. So I wouldn't expect to find out lots of information about what's going on with Tufted Puffins by looking for dead puffins on the beach, but I would expect to find out information about murres by when and where they wash up.

And the other thing about murres is, unlike many seabirds, murres belong to a family where some members of the family have chicks that leave the nest when they're still pretty young. So, they're a little bit like chickens that way, the young become autonomous before they're fully adult sized. And in that case, we can see the patterns of adult mortality vs. young of the year mortality. And that's pretty important when you're trying to figure out things about population dynamics. You want to know whether there's a very high number of kids dying, or just a few, and whether that ratio of kids to adults changes from year to year. And so all of those things I knew that I could get from just the patterns of birds dead on the beach. And we can also kind of play CSI and figure out what killed those birds: was it starvation, is it an increase in predators in certain locations, is it disease, is it something else? Doing all of those things would give me a regional context within which to put my much, much more detailed colony data.

So that's why I put COASST together. I knew that I would never have enough money to pay people to do what I wanted, so I thought to myself, "well, you know, maybe I can get participants." At the time, I hadn't actually looked around in the literature to see what other people were doing – there are certainly beached bird programs in other places in the world that predate mine by decades. But I hired a grad student from the University of Kansas, Tom Good, and he spent one part of a summer on the south coast of Washington where the beaches are very flat and sandy, and you might think maximized for receiving flotsam coming in on the tide. Tom went up and down these beaches daily and looked for carcasses – he's a seabird biologist as well, in fact he works now in Seattle here for the National Marine Fisheries Service, so identification was not a problem – and tagged them so that we could figure out how long they lasted and whether they moved around and who ate them and all those kinds of things, and we could also start to test out different kinds of carcass tagging techniques. At the end of that summer we looked at all the data and thought, "wow, we really can see all of these interesting signals," including signals about murres. So I decided that what I wanted to do – instead of trying to work on live murres on colonies everywhere on the west coast – was to keep one colony working and then try and look at dead birds. But then my challenge was, ok, who am I going to get to do that? Because I was still in that same conundrum of, well, if I have to find enough money to pay graduate students full-time and technicians it's still going to cost me millions of dollars – I don't have that year in and year out. And so I decided that maybe I'd try to mount a citizen-based program to do that. So that was the genesis of COASST. Long-winded story, but there it is.

What I really wanted to check out that summer was what Tom would find on beaches. He really acted the part of many people, that is to say, he walked miles and miles and miles of beaches, and got enough information to show us what patterns beyond one individual might look like. That told me, ok, this is going to work. But it left two large gaps. One was funding. Even with a volunteer program, in my opinion, you need a stable and sometimes fairly high funding base to make things work. That's because you have to come up with a training program and materials that are good, and useful, that you can get out there on a regular basis. You have to have a way of collating the information that comes back in and turning it around and getting it back out to the participants to show them what they've learned. And all of that takes a fair amount of funding, so I knew I had to find funding. And then we actually had to invent how to identify dead birds, which sounds like it should be easy, but it's actually not. Tom was a seabird expert, so it wasn't a problem with him. He knew what he was looking at, and I had confidence in his abilities. But when you reach out to a broader sector of the community, you know that you're not going to… I mean, you can probably mop up all of the itinerant seabird biologists on the west coast and you've got maybe 20, 25 people. And I had a vision of more than that.

I thought about it as a Huck Finn[2] paint-the-fence thing. I knew what I wanted – I wanted more regional information about this one bird, the Common Murre. And so I thought, ok, we have to be able to teach people to do this, and the teaching can't take forever, and it has to be reliable, and we have to do it in a way that we can independently verify, so if somebody writes to us… well, let me back up. If somebody's doing the Christmas Bird Count, or Fourth of July bird count, and writes in that they saw 50 whooping cranes, there's no way to verify that individual sighting, because it's sort of an honor system. The way that we get around things like that is we look at the data regionally, and if we see outliers or pieces of data that really don't fit in with the surrounding pattern we tend to discard them and think that they're not correct. That works if you have a program where there's thousands and thousands of people contributing. But with tens to hundreds of people contributing you have to pay a lot more attention to individual pieces of data. So we had to solve that problem.

We had a few problems to solve, scientific problems and training problems, and financing problems, and that took two years or so past that original time when Tom was walking beaches. And was a real transition for me. I think, at the time, I still was pretty steeped in thinking about it from my own point of view and the kinds of data that I wanted. And I wasn't really thinking about what the experience of the participant would be. That only came later, when participants started to tell me what their experience was, and it made me think, "huh, there's something else going on here besides just helping out a scientist."

I was certainly aware of programs like the Audubon bird count program. In fact, when we started COASST, the first thing that I did was go to a local Audubon chapter on the outer coast of Washington, and interestingly enough they turned out to be exactly the wrong people to be COASSTers. The people who are serious birders in Audubon want to see the next new thing, they don't want to see the same old thing, and in COASST, you tend to see the same old thing. It's that pattern of sameness that gives us the information that we need to figure out what's going on with populations. People who want to check off the next thing are really bad COASSTers, it turns out. And who knew? Because you would think, these are people who love birds and they know about bird identification. It seems like they should be just the right community. But, it turns out, I think that they're the wrong personality. And so that was a really interesting insight for me, that for instance in that set of people that you might put as, "love birds," – there are all sorts of

[2] Julia's reference here is actually to Mark Twain's character, Tom Sawyer.

different people, and they like to do different kinds of things, just all centered on birds. So that made me think a lot about who makes a good COASSTer.

I ended up with twelve people in Ocean Shores, Washington, as our proto-participants. They were the transition, once we developed all our materials and tested it out on ourselves and our grandmothers and everybody else we could think of, to make sure the field guide was jargon-free. Then we had this misstep with the Audubon Society, and then after that we went and we recruited just generally in the community, found these people, and they worked with us I think for about a year, going out on a monthly basis, and trying out our materials, and phoning back in and saying, "hey, you know what, this is not working, I can't figure this out," allowing us to really refine what we were doing and how we were asking them to collect information, and how we were asking them to make identifications. And so based on that, I would say that the larger program grew out of that interaction.

Tom worked in the place that we decided to start in. Coastal Washington, like coastal Oregon and northern California, is studded with relatively small towns. Even as an outsider to town, if you're staying there for a while you can kind of get to know what's going on, and you know the places in town where different kinds of people gather. In the town we were working in, Ocean Shores, there's a small nature center called the Ocean Shores Interpretive Center. It's run by a set of locals, and they're wonderful. We knew about that from Tom's work, so we ended up calling them up and seeing whether they would help us, and help us find people, because they were – and still are – a kind of magnet in town. And they were overjoyed, and said of course they would do that, and so they helped us recruit the initial folks. In fact, that general strategy of finding the place in a community that's likely to be a gathering place for people that you think might be your participants, and also if possible finding the person, or the people in town that are the social networkers for things science-y or environmental, or ecological, that works really well. That's what we did. And aside from a few participants who have passed away, I think we have 100% retention rate in that town.

Our participant numbers fluctuate a lot, and go down a little bit in the winter because we tend to lose people from the north in the winter for obvious reasons. We're at about, I would say about 600 people at the moment[3]. Yeah, and I have to say, who knew? I thought when we originally started the program… so we got some funding and put the program together for about a year and a half before we started to run with participants. And I assumed that maybe with a lot of work we'd get to 50 people. And I misjudged people a lot. Which is… that's a happy mistake, I think, for two reasons. One is, I have a lot more information, so that's a pretty selfish reason. But another one is that I found out along the way that people are very, very hungry for ways that they can participate

[3] Julia gave this estimate during our first interview, in January of 2011. Over the course of a year and several interviews, COASST grew to over 700 participants.

meaningfully in something that gives them information about what's going on in their local environment. There are a lot of people who would love to do things like – I call them citizen involvement, or service things – like participating in a beach clean up, or planting trees along a restored creek bed, you know, lots of things that really help the environment. People love to do those things. But those things don't give them information about what's happening. They just make… they're like small fingers in the dam. Citizen science, real science… so real citizens and real science, goes a long way, I think, to making people feel like they're involved. And it turns out that those same kinds of feelings and interactions that you see in kids when they're in science museums or imaginariums, before they've been told that science is hard and there's a lot of math, and they have to study, and all of that stuff, when they're just discovering things like gravity, and it's really fun, and you can see it on their faces, and they're racing around and they're trying everything out, and it's just great, and they'll tell their parents about it… I think that that feeling in some measure is possessed by everybody. And I think that when people get involved in citizen science it reawakens a lot of that wonder, but it mixes it with a lot more adult knowledge, so people want to do well, and they want to figure out what's going on, and they want to see that information. And so I think that that's why I can get so many people to walk beaches and look for dead birds, which as a stand alone fact is kind of odd, when you think about it. But it's because it's in that larger context of knowing, and participating, I think, that it's so successful.

But we expanded really slowly, which is a really good thing. If we had expanded fast, we wouldn't have been able to do it, just because there were hiccups and glitches that we had to solve, like any program I think. So that was the lesson that we learned along the way, to try and figure out the community dynamics of the place. Now in general we're big enough and we're known enough that we tend to… we're certainly constantly going back to the places in which we're already established, and that's because we want to connect with the participants that we have. There's always a certain amount of attrition, and so we need to replace those participants that have moved on to other things or literally moved to other places. We will do trainings when people ask us. We now get lots of calls from individuals saying, "Hey, I've heard about you, will you guys do a training in my part of the world?" And that will cause us to look at their part of the world and see whether we can do that or not. But that kind of sussing out the place and finding individuals works really well. It's impossible to do it any other way when you get to places like Alaska, because everything is so, so, so dependent on the community, that you just can't get a foothold unless you know the right people.

When I started, I had all of these thoughts about how we would be making decisions about where to go, and how we would make decisions about which beaches to put people on and they were all very scientific decisions. For instance, in Washington – and this is also the case in Oregon – the state government has paid for a very high resolution set of overflight cameras to take standardized photographs of the entire coastline in exquisite detail, and that same agency has come along and typed all of the beaches into 15 different substrate types, and so I have a huge amount of information about what kinds of beaches there are in Washington and where exactly they are. It turns out that there are many things other than presence of carcasses in the water that affect how many you'll find on a beach. And they include the angle of inclination of the beach – a steep beach vs. a fairly flat beach will make a difference. Flat beaches will grab more stuff than steep beaches will. And also the angle of orientation, that is, a beach on a peninsula that's facing out into the long shore current direction, that'll make it a grabby beach, and if the current's going north, the beach on the south side of the peninsula will get a lot more things than the beach on the north side of the peninsula. So you have to take inclination and orientation into account. And the third thing you have to take into account is what the beach is made up of. Beaches that grab least are rocky beaches. That is, just as if you paved a road, and that's literally because the water and things in the water just slide right off rock. If you break up that rock into big boulders, then things will get caught in between the boulders and you'll get some retention. And as you move from boulders to cobbles to pea gravel to sand, things will get more and more grabby. That's because sand not only will cause a lot of friction – think of sandpaper – but also as soon as the sun comes out and the wind starts blowing, the very top layer of the sand will dry. And then that sand will start moving around. Think of sand dunes. And as soon as that sand starts moving around, it starts to immediately cover or partially cover everything that's on the beach. And that anchors stuff on the beach. So even in one half of a tidal cycle – that is, the tide is high, it's going out, and it's leaving things on the beach until the tide turns again – if it's a blowy day, those things will start to get anchored. And so a sandy beach is much more grabby than a cobble beach that has exactly the same inclination and orientation.

I thought to myself, "ok, we're going to do this scientifically, we're going to sub-sample all of these different kinds of substrate types, and as we move into various communities in various places it's really important that we tell people to go to these specific beaches because if there's 35% sand in your general community then I want to make sure that 35% of the COASST beaches are sand and…," you know, on and on and on. Ok, well that doesn't work at all. You can achieve those kinds of things regionally, because you have lots and lots and lots of people. But when you tell somebody, "No, I'm sorry, you can't go walk on the beach that you walk on every day for our program, you have to get in your car and you have to drive 8 miles to this other place, and that's where you have to survey because that's the scientific thing." I can tell you what they'll do – they won't participate in your program. Citizen science, I have come to learn, is not just about people doing science, it's about people doing science connected to a place or a thing that they love. And if you break that connection, they become the kid in school again. So sometimes they might do it, but often they won't, unless they have to. And people don't have to do citizen science. So you have to – my experience has been that you have to find that connection, and then you have to celebrate it. And then people will stay with you for a very long time.

When we had small sample sizes, this would affect the science. And when we go to a new place – so for instance Alaska is a real challenge for us, for a few reasons. One, it's huge. Two, it's very sparsely settled, so you have a community and then it's three or four hundred kilometers before you hit the next community. And so the thought of getting even samples across beaches in Alaska is crazy. We know we can't do that. Communities are very small. The weather is pretty fierce. All of that means that the chance that you're going to get a huge number of people to really fan out and give you a good sample size is crazy. I know that we're not going to do that. So I'm actually still on the fence about whether or not the information that we're getting from Alaska is good enough to say something scientific. I'm also very on the fence about whether we will ever be able to capture the degree of pattern that we can in the lower 48. And that's just because of sample size issues. So maybe if I was just thinking like a scientist I would say, "well let's pack it up and get out of Alaska," because it's hard to work there and the cost to us in dollars per beach added in Alaska is tons higher than it is in the lower 48 for all sorts of reasons. But, there are a lot of people in Alaska that are really committed COASSTers now, and that number is growing slowly but steadily. I can see that, while it's been very hard for us to get into communities and be stable, we're now stable in a bunch of communities and those anchor people are beginning to add other people one at a time. The process in Alaska is working a little bit like it did in the lower 48, it's just taking more time. And so I'm really careful of the scientist when I'm thinking about what are we seeing in the overall pattern of things in COASST, whether I want to include the Alaska data or not[4].

But in the lower 48, our program is large enough that we have coverage almost everywhere. So now, for instance, if I looked at what's the substrate type of beaches that our participants walk across a single state – Washington, for example – or we actually look at smaller parts of the state that have similar geomorphology, now it approaches exactly what we see if we look at those detailed photographs that I told you about. So you can get there over time, and I think that's actually a much better way to go if you're running a long-term program. If you're running a short-term program, then if you have scientific funding to go out and do some experiment and you need volunteer help, then you just don't have that time. Then you have to get people to do exactly what you want them to do in the places that you want them to do it, immediately, and I think that's a different kind of thing. I can't imagine, for instance, thinking that I would in, let's say 3-6 months, ramp up COASST to where it is now and train hundreds and hundreds and hundreds of participants and get them out there all collecting data, because we were

[4] Julia commented on this statement in review, "hmmm. i've totally lost my own train of thought here. don't know whether i meant that i'm careful of being the scientist bc there are other considerations that are equally important (like the people!), or that i'm careful of using the Alaska data in science bc it's sparse, or both. right now this statement is a conflation that doesn't make sense to me."

doing something where I needed this year of data or these two years of data and then that was it. I mean, maybe that would be possible, but I don't think I could do it. We got to where we are now because we decided to make a commitment to be a long-term program.

The first hurdle was kind of an ownership one, I think. I tried to shop this idea around in Washington for a while, and I did get some very positive feedback from some groups and particularly from some agencies and people in agencies, but they tended to say something like, "wow, that's a really good idea but we should be doing that, the university shouldn't be doing that, you shouldn't be doing that, we should be doing that." And I would say, "great! Do it!" and then nothing would happen. There's this weird kind of thing like, "we are the stewards of the resource, that's our job," but then they didn't have any money or any time to do it. And so I thought, ok… but my first question was, although it's really good to go talk to people about an idea, at the end of the day you have to decide whether you personally want to do it. And if that answer is yes, then you personally have to go out and make it so. And so I decided to take a different approach and I went to some private funders, some foundations. And so COASST was actually started with a grant from the Packard Foundation and honestly, without that grant, COASST wouldn't be. It was very funny because, I will always remember this, the amount that this has happened in my life – actually, more than once, but not very often – I've had a funder who has come to me and said, "Hey, that's a really good idea, we'd love to fund that," and I submit a budget and they call back and say, "You know what? That's not enough money, you need more money." And when that happens, you just think "What? Really?" Like Christmas and your birthday and winning the lottery all at once.

I knew Nancy Packard very distantly, because we had both lived in Monterey. She had actually been a part owner of a film studio that I had friends at and I knew that she had moved up here to Washington State. And she's a pretty private person, but when I was getting turned down by all these agencies and there was all this weirdness about who should or shouldn't do something or is the steward of something, I was talking about that to my friend in Monterey and she said, "You know what? You should just write Nancy and see what she thinks," and I thought, "well, ok," and so I did. I wrote her a letter about what I wanted to do and why, and I never heard anything. And I thought, "well, that's ok, she probably wasn't interested and we only met a few times, so it's not a big deal." And then one day I got a call from the Packard Foundation, and they said, "we're really embarrassed but we can't find the budget for your project," and I thought, "what project?" And so I kind of was listening to them and thinking, you must have the wrong person, and it became apparent that they in fact were talking about my project, so I said to them, "you know, I have to tell you, I didn't write you a proposal, I wrote a letter to Nancy Packard," who was, at that time, on the board. And I said, "so I don't know what to say about this," and they said, "we know what to say about this, we don't care how the idea came in, it's a good idea, we need a budget but we need it by 4:30 tomorrow because the board's meeting." And I thought, "ok...." So I sent them a budget and that's when they called back and said, "no no, that's not enough money." So that's how I got the money. I know, it's a great story.

So that's what happened. They actually doubled the budget that I had originally turned in to them. And in retrospect – I was pretty young then – in retrospect that made a lot of sense because they wanted to invest enough money to increase the probability that it was going to work. Because otherwise it's definitely money lost for them. So that was great, and they started us off. And because we had a large enough grant, it meant that I could hire somebody to be a full-time COASST employee and work on the materials and so I did that. That was COASST's first trainer, Todd Hass, and he developed the field guide with me and put trainings together with me, and did all of that stuff. There was enough time to think and argue and put stuff together and test it out, and then redo it and adaptively manage. So that was just great. I recommend when anybody comes to talk to me about how, "I want to put a citizen science program together, to do…" whatever it is they want to do, "how'd you do it?" I say go find a funder who's going to allow you that time and space to do that, because once you have the materials together, then you're golden. But if you're trying to train participants, lots of participants, at the time that you're also trying to spin things up, you cut corners and then it doesn't work so well.

But to go back to the state agencies, we also have a link to NOAA and the National Marine Fishery Service within NOAA. And that is because we are experts at identifying dead birds, and that process is a little bit different than identifying live birds. NOAA is responsible, among many other things, for training fishery observers that are put on active fishing vessels in all sorts of different fleets. One of the things that they have to do by law is monitor the presence and certainly the death of listed species under the Endangered Species Act, and that includes a bunch of birds as well as all kinds of fish, so they need to be sort of a jack-of-all-trades of identification. And if the birds have been caught in the net, or on a hook and dragged under, and they come back on board several hours later, they look very, very different than they might in an Audubon or Sibley field guide. It turns out that our field guides[5] are extremely useful to the observers, so we also do observer training for many observer programs, and we work closely with the people who run observer programs in federal fisheries departments. Which is really odd, when you think about it – I mean we of course didn't design COASST to do that at all, but that's a good example of how another organization has come and looked at our stuff from a slightly different point of view and said, "hey, you know what? That could be really useful to us. Why don't we take this part of what you do and plunk it over into what we do?" So our trainers in COASST will go train the Snohomish County Beach Watchers to take over three or four new beaches in their county, and then two days later go train observers in Alaska that are going to go out in the pollock fisheries in the Bering Sea. And it's the same

[5] Available for purchase from the COASST website: http://depts.washington.edu/coasst/news/publications.html

identification process for both of those user groups, but the way we frame it is of course entirely different.

There are certainly a lot of people throughout the marine science community, which flows over both academics and government agency labs, who are really positive about the program. And I know this, because they'll call up or want information, want to use the data, and get us involved in all sorts of offshoots in which our data are component modeling – eco-system based management, and models and seabird biology things. If they didn't have confidence in the data, if they didn't think it was a good idea, they wouldn't do that. And in response to professional papers and presentations from COASST, I would say everybody's polite, which is kind of unusual in our community. Some people are – you know, it's like anything. Any conference you go to, the people that are really jazzed are the ones that are going to come up to you afterwards and say, "Wow, that's great! I want to do that, I want to find out more," and the people that are not, aren't going to come up and talk to you. And so that's fine. It's kind of hard to sort out, to assess the proportion of people who think it's a good idea vs. are being polite.

You know, I think that all communities, affinity groups, have their secret handshakes, and science is no different. So scientists tend to believe other scientists, and rank the credibility of people according to how many layers of the onion they are out. And so that's one issue. And then another issue, which has become really big in I would say the last decade, is that many, many, many programs call themselves citizen science, and although there are a lot of citizens, there's no science in the program. So as a term, the scientific community tends to turn away from stuff like that, because to them it's a parody of what they do, or in fact doesn't resemble what they do at all. And although they can appreciate the interactive aspect of it, it pisses them off to have their term appropriated as I think would the medical community or the legal community if that happened on a regular basis. At the same time, a citizen science program that's run by a credible scientist, somebody who is also doing science other than the citizen science work, or is a professor at a big university, or a research scientist at a government lab, those people have a degree of credibility that gives them an entrée into talking with the scientific community about the citizen collected data. So that's one thing. That is to say, it was easier for me, I am absolutely certain, than if I had been the very same person but working, say, within a non-governmental organization, starting the exact same program, doing the exact same stuff. If I worked for TNC[6] or WWF[7] I know that I wouldn't have gotten the credibility that I got and that I have as a university professor. So that's one thing, because I'm already in the group.

And then the other thing is – and I didn't do this because I was worried about my colleagues, I did this because I was worried about the information – I wanted to

[6] The Nature Conservancy
[7] World Wildlife Federation

absolutely know that I could figure out a way to make sure that the data that were coming in were real. And so what we did was design an identification procedure that incorporated ways of collecting information so that we could check out these data independently. So, let me back up. When our participants encounter a carcass on the beach, the first thing that they do is note the type of foot that the carcass has, and they write that down. And then, depending on which body parts are present, they take up to three particular measurements, of the wing, and the foot, and the beak, and they record those three measurements. And then they open up the key and go through the process of identifying the bird. Then they take scaled photographs of both surfaces, belly and back, of the bird, or what's left of the bird. And all of those things together – the type of foot, the measurements, and the photograph – allow us to verify that when they say, "Common Murre, juvenile," we agree. And we verify each identification in the lab, so if we get 10,000[8] carcasses identified in a year (and that would be a big year for us), I have somebody in the lab that's looking at every single one of those data lines that a participant is turning into us and verifying it. We're also taking some of those and then sending them out to experts at museums and different places so that they can verify that we are correct. So there's a chain of verification that goes on. That means that our IDs are pretty iron-clad, and we can track them because our participants mark every carcass individually. We do that because we want to see how long it lasts on the beach, and which body parts last the longest. But it also means that number 57 on Ocean Shore beach number 3, can't go from being a Rhinoceros Auklet one month to being a Common Murre the next month. And if it does, then we can figure that out. We can also track how accurate our participants are at identification, and if they're not very accurate we can give them more training, which is something that they want, because they want to be correct. So when we designed the program we designed it in such a way that it's really focused on very, very, very high quality data.

Now the one part that is hard to get a handle on is how accurately people walk the beaches. That is, if you are surveying a beach, you're actually doing a very different pattern of walking a beach than if you, say, go out with your husband and your dog and you take a walk on the beach. In that case you tend to walk right next to the person that you're with, and you tend to walk in a straight line, and you tend to only half look at what's in front of you because you're busy in a conversation. Whereas if you're searching a beach, you walk in a sinusoidal pattern, a big S curve down the beach, and you tend to divide the beach into width segments. From the tide up to the vegetation it can be a very broad or a very narrow beach, which means that you have to walk back and forth on it for different amounts of time. Participants learn to do all that, and we need to know that they're actually doing that. And the way that we figure that out is we look… this is kind of like the Christmas Bird Count thing. We look to see whether the general patterns in

[8] In reviewing this document, Julia clarifies that 10,000 carcasses in one year might be a bit of hyperbole. The 2009-2011 COASST Report noted 9,667 carcasses found over that two-year period. http://depts.washington.edu/coasst/news/publications.html

terms of numbers of birds from one beach to the next within a region of similar substrate types are the same. So if we have somebody who's finding 40 birds a kilometer, and 40 birds a kilometer, and 40 birds a kilometer, and the beach next door is only finding 3, we go check that out. All of those things make our data very credible.

The research that comes out of COASST is opportunistic in a variety of ways. And by that, what I mean is that the program itself was not set up, designed, explicitly to answer a particular research question. And that's important to note, because often when you have a research question in the field what you're trying to do is establish and then understand – establish that a pattern exists, and then understand the underlying processes that are creating that pattern. And in order to do that second thing, you have to do the first thing first, and then have some sense, even a vague sense of scale in time and space of that pattern so that you can set up an experiment or a monitoring protocol or whatever it is to capture the pattern in the relevant scale. So for instance, people often talk about in experimental design, you need some sense of variation in order to get a sense of what sample size will allow you to understand whether some forcing factor is significant or not. And that's just a fancier way of saying you have to understand the scale in space and time of the pattern. COASST was not set up to do that. We had some grand plans originally but they got pretty dashed by the realities of citizens and what they want to do. So the current composition of the program in space and time is, I would say, more relevant to the realities of where people live and how far they go, than it is to answering any particular question. Having said that, in places where there are a lot of people, like the lower 48, and especially where there are coastal communities that are fairly frequent as you drive down the coast, we get a fair amount of coverage. And that coverage in fact is usually, but not always, enough to oversample for any particular long-term or longitudinal question that you might want to ask. That is to say, we could take the COASST data for say, the outer coast of Washington and Oregon and into California, and we could put it all in a big bag and we could sub-sample out of it and establish a pattern, like the migrational timing of non-resident Alaskan species on the coast, with far less data than we actually have. Once we get to that point of oversampling, then data can be used for all sorts of different things. And because there are many years now in the data set, people come up with all sorts of creative ways of asking questions of the data. Questions that I sometimes have thought about, but often ones that I had never even thought about before. So the data as it becomes rich in space and time, where time is years, not days, that is, not intensive sampling frequency, all sorts of people use it. So we use it, and then other people use it to ask and answer questions. That's the first kind of opportunity.

The second kind of opportunity is that people – sometimes us, and sometimes others – will say to COASST, "hey, if you just collected this other piece of data in this one set of locations or changed your sampling frequency for a little bit of time, that is for a few months or even a few years, we could answer this other question with the very same survey protocol that you have." And so we'll do stuff like that. For instance, we had a project that framed some beaches on either side of the Columbia River, where we're trying to get at whether or not the deposition rate of carcasses was affected in the short-term by changes in the wind speed and direction. We're just finishing up the analysis on that question. So there is a different kind of opportunity, where we're not saying to every single COASSTer, "hey, change what you do," but we're going to a particular place in the COASST region and we're saying, "hey you volunteers, what do you think about participating in this extra project?" And for those who are interested in that we set them up. Another example of that is we worked with the Department of Fish and Wildlife in Washington to see whether we could develop an early warning monitoring protocol for avian influenza. There of course you don't want to say to all participants, "hey let's monitor for this deadly flu." You want to say, "for those of you who are interested in doing this, you can do this extra thing." So that's a second kind of opportunity, the layering on of some additional stuff, often an intensification of data collection. Sometimes collecting additional information.

And then the third kind of opportunity is when people decide to look at our data and that provokes another question. An interesting one to me was an anthropological paper, because I had no contact with the first author. She sent that to me after it was published and said, "hey, I just want you to know I found your website and it had some really interesting stuff on it, and because you had some data in your report that was interesting to me, it made me start thinking about wrecks of seabirds and that being the source of all of these bones that we were finding in the middens[9], and so I made that connection, based on something that you'd written, and so we included you in the paper[10]." That happens rarely, but it's happening more and more as people become more acquainted with COASST. Mainly it's the first two routes, that somebody comes to us and says, "hey, can we use your data to look at this specific thing?" Or comes and asks us to layer something on top of what we're doing. Which usually ends up being a short-term thing and a small space thing, that is not everywhere.

I would say the core of COASST is to create the basic monitoring data and then use those data to look at all sorts of different things. So that longer term kind of baseline, month in month out data, allows us – has allowed us to look at climate impact[11], fishery impact[12],

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[9] Middens are historic mounds of bones and shells, presumably from cooking waste of past settlements. Long researched by archaeologists and anthropologists, they are increasingly used as sources of ecological insight, particularly related to global change.
[10] Bovy, K. M. (2007). Global human impacts or climate change?: explaining the Sooty Shearwater decline at the Minard site, Washington State, USA. *Journal of archaeological science*, *34*(7), 1087-1097.
[11] Parrish, J. K., Bond, N., Nevins, H., Mantua, N., Loeffel, R., Peterson, W. T., & Harvey, J. T. (2007). Beached birds and physical forcing in the California Current System. Marine Ecology Progress Series. 352: 275-288.

and oil spill and chronic oiling impacts, sort of all sorts of different things, phenology of breeding and migration, goodness. We're endlessly finishing an article on harmful algal blooms at the moment. So when you have a monitoring dataset that begins to extend over years and then into decades, and is geographically large, it suddenly opens up many, many possibilities in terms of issues and questions that you might ask. And I think that we're at that point in COASST, so essentially there are more questions that we can ask than we actually have time to ask, and really dig in and analyze. Which is a great place to be, I have to say.

I started COASST before I received tenure. And, gosh, I'm a weird case that way, because I was a research professor for quite a few years when I was an assistant professor. Basically what that means is I didn't have what's referred to as a tenure track line, so I brought in all of my own salary, the University didn't pay me. I actually did teach a little bit, they would pay me to teach. I switched and became a tenure track professor the year right before I got tenure, and I also received a joint appointment across fisheries and biology. When that happened, that was basically a signal that the University wasn't going to throw me out at tenure decisions, and so that made my tenure decision odd. So I didn't actually go through that thing of trying to look at what I was doing, my research, and say, "What should I cut out, or what shouldn't I do, what's risky and might not get me tenure?" I never had any of those thoughts, and so starting in citizen science, it never actually occurred to me that starting a citizen science program might put me in at odds with some of my colleagues who were deciding on my future.

But at the time that I started COASST, COASST was the vast minority of what I was doing, so there wasn't any question. When I started COASST, I was maintaining a really large lab. I had, I don't know, well let's see when I started COASST I was also running a very large multi-state, eleven principal investigator, 4 million dollar program. So, when people looked at what I was doing in science, COASST was like a blip on the radar screen. Now it's a larger thing in my program, but still – I mean I can tell you that although COASST has certainly been steadily funded over its entire lifetime, and right this year is pretty well-funded through grants and contracts and has four employees, I also maintain other grants and contracts and have other people working for me in my lab. So whenever somebody – whenever one of my colleagues from U Dub looks at me, or one of my colleagues from outside, it's not that they just see COASST. COASST to them is one of several things that we're doing. If I had to imagine what it would have been like if I had

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[12] Hamel, N. J., Burger, A. E., Charleton, K., Davidson, P., Lee, S., Bertram, D. F., & Parrish, J. K. (2009). Bycatch and beached birds: assessing mortality impacts in coastal net fisheries using marine bird strandings. *Marine Ornithology*, *37*(1), 41-60.
Moore, E., Lyday, S., Roletto, J., Litle, K., Parrish, J. K., Nevins, H., ... & Kell, S. (2009). Entanglements of marine mammals and seabirds in central California and the north-west coast of the United States 2001–2005. *Marine Pollution Bulletin*, *58*(7), 1045-1051.

only been doing COASST, if I had been concentrating all of my effort on citizen science and nothing else, then I can imagine that tenure probably would have been an issue. Not because of the citizen science, but because of the delay. That is, when you're collecting monitoring data, it's really, really hard to use those data to say something scientific in a short period of time, like a year or two years. You need some time and also –basically you need some scale, in space and time, to be able to discover patterns.

I do struggle with how COASST fits within the larger scope of my professional activities, and I'm betting that any academic that has a citizen science or even just a citizen engagement program probably struggles with that. Certainly the COASST program is old enough now that it has a large dataset, and so that's now usable by several people, certainly other than me, and some of those people include my graduate students who are not working in COASST at all, so that's not their graduate work, their graduate work is usually live seabird work, seabird ecology, but they have found that they can use parts of the COASST data to help them answer or direct questions. That's one avenue of intersection. Another one I would say, and this is much, much more recent, is that there's been a bit of a wave of interest in citizen science among ecologists in general, and I think that's coming from several different places. Certainly one of them is the National Phenology Network, which has been giving out some funding for folks to start incorporating citizens in their phenology studies – and so there's a lot more buzz about citizen science and I'm finding that graduate students in labs other than my own are very interested in citizen science[13]. So there's a connection that's being made there just because our program is older and we've learned a bunch of lessons, so there's a lot more sharing and interaction surrounding, "well, how do we do this?" And, "what are the good ways and bad ways of doing things?" And I find that to be very different than it was even five years ago.

But I made my program up first, and discovered citizen science as a sort of entity second. So I had no real knowledge of programs in which scientists train people and collect information. I had also no knowledge that there was any sort of central organization. I didn't even encounter informal science education until, gads, six or seven years after I started COASST. I was extremely insular, as a classic scientist is, so I did it in a bubble. I think it wasn't until we were throughout Washington and down in to Oregon that I discovered that there was this whole other thing going on with citizen science and started to get involved and read more about people who were interested in education, not in seabird biology.

I guess I could certainly say that I myself am an educator. I'm a professor at a University, and do a lot of teaching – actually not at the moment, but I have done quite a lot of teaching – of really large classes and non-majors classes, and I love teaching. I really love

[13] Since interviewing Julia, she coordinated a multi-year graduate research seminar that focused on researching scientists' perceptions and use of citizen science data.

showing people pieces of information, but more than that, showing people how to do something themselves. How to go find information, how to gain a skill that they don't have, and help them to hone it, to use it. I think we put all of that into our training program for COASST. And it's always struck me that our concept of education in this country… that we put our kids through school, and certainly for many families but definitely not for all of them, there's a notion that if you can go to college, that that seals the deal of your future. And so here we are putting all of this time and effort into training our youth, and then you get to be 21, maybe 22 years old, and it stops. And society says, "well, you know, you're an adult, you know enough, go get a job." And, that seems crazy to me, when you think about it. There's nothing in our biology that particularly says, gosh, the learning cells turn off at 22, it's just the way our culture has evolved. And so, it seemed to me that you should be able to train people to do anything, and the difference would be that people would only get involved if they wanted to, whereas within a school context, people get involved because they have to, because they're told to.

And so what I actually wondered at the beginning was not, could I train non-scientists to identify dead birds and search in a standardized fashion, I knew I could do that. I thought that there just wouldn't be that many people that wanted to do that, because it's kind of a weird geeky thing, and dead birds can often be, well, rather unsightly, to put it mildly. So I didn't anticipate there were going to be that many people who really wanted to participate. And that's where I was really wrong. And I think that maybe if I had come late to the field… I mean, it turns out that the COASST program was sort of early to the field of what I call rigorous citizen science, so, you're really asking people to do deductive reasoning, not just be a messenger going out and collecting something, or taking a photograph of something. My sense is if there were fifty different citizen science programs here on the west coast that all focused on the beach environment, which is a very attractive environment for people, then I probably would have had a hard time getting a purchase, but there aren't. There's hardly anything. So people are really searching for something to participate in. And I think that that's why our participant numbers are as high as they are.

When I first became aware of the ISE program at NSF it was because some guys that I knew in WWF had gotten an ISE grant to work in coastal communities in Alaska. They were trying to figure out what to do, and they had heard about the COASST program and wanted to see whether we could come up to Alaska and be part of their program. And so they actually ultimately funded or helped to fund – significantly helped to fund – the production of our Alaska field guide, and were the reason that we're in several communities in Alaska that we're now in.

In some sense Alaskan partnerships are not different from partnering with the coastal tribes on the outer coast of Washington, except that the logistics of getting there is much more difficult. So I can drive out to Neah Bay and work with the Makah tribe or drive down the coast to work with the Quinault or the Quileute – but for me to get to an Aleut community, I have to fly to Anchorage and then get a puddle-jumper flight out to the islands. And in a really small community there's often no place to stay. I have camped out in the Home Ec. room of various high schools over time because there's no hotel or motel or anything like that, and everybody's house is full of people. And I just spent $2500 to get there, so the logistics cost is really high. But when you get there, you receive the same amount of warm welcome mixed with very open distrust that you get on the outer coast here with the tribes – and that is because quite literally, you're dealing with a community of people that are survivors. They have survived at least centuries of pretty open abuse, often ending in death, of the people in their community. And so their stories of interactions with westerners are not great, even to this day.

So getting involved with a tribe is not simply coming to them all smiles and saying, "hey, we've got this great opportunity, we can involve you in science and you can learn more about your local environment." That's really arrogant, to say to a people who have lived in an environment for centuries, and know it in a whole bunch of different ways, western and otherwise, that you somehow as a post-doc or a professor know more than they do about their own land, or their own part of the ocean. So it takes a long, long, long, long time to get involved. And a lot of people will get money to go do something in a part of the ocean or a part of the world that has an indigenous culture, and part of that is to try and integrate into that culture to some degree to extract information, and often because of those logistics costs it's extremely expensive to do that, and the flow of grant resources is not unending that way. So you can get a grant from NSF or NOAA to go do a 2 year study, but you're not going to get a grant to do 10 years or 15 years or 20 years. Grant money doesn't flow that way, really. And so from the native culture's point of view, here are these weird people, they're coming in, they spend a year or so, they're up there, they're talking to you a lot, you say, "Ok, well, I'll let my guard down, sure, we can do this thing," and you may even make some friends, and then – they're gone. And your opinion on the matter is, "well, what the hell happened? We just opened up our houses to this person or these people and now where are they? Why aren't they working here anymore? And, what did they find?" And often the scientists don't completely understand, if they understand at all, that the production of a scientific paper, written or oral, is not what a community wants.

I'm not ready to give up, but gosh, it's difficult. It costs us, in time and money, so much more per beach in Alaska than in the lower 48. The thing that's keeping me in Alaska is actually the same thing that's keeping me running COASST. And that is that whenever I get overwhelmed or depressed by the tidal wave of problems, I get a phone call or an email from an individual participant that says something like, "Oh my god, you guys are so great, this is such a wonderful program." In Alaska, there's a guy who is the middle school, high school science teacher in a little community called Shishmaref. Shishmaref is up around the corner from Nome, in the Chukchi Sea, which is above the Bering Sea. It's framing the Arctic. It's a place where ice-up happens sometime in the late Fall, and break-up happens about June. It's a very small Inupiaq community, I believe. And this guy is amazing. He's western, he grew up in Seattle, and he moved up there as a science teacher and he married into the community, and he's got a passel of really great kids, and he became really passionate about all things natural, and he's also a great photographer. And he loves birds, and he heard about our program, and he communicated with us and said, "Can you come to Shishmaref and teach us? We want to start beaches." Well we met him, but his passion is to involve his community in lots and lots of different ways, one person at a time. One kid at a time, or one adult at a time, he's in it for the long haul. And he is just – he's one of our most passionate participants and supporters. It's just amazing. And we get communications from him and I think, "This guy is up there, almost at the Arctic Circle, he is totally committed to his family and his community and his life and teaching, and he's using us in a totally positive way as a vehicle, and he's searching for other connections and we're helping him to find those connections. Who am I to back away from that kind of passion?" And so I think, "well, ok, that's a great reason to keep going." It's not a scientific reason at all. But, boy, is it making a difference on a local scale, one-by-one. And at the end of the day, I really think that that's all you can do.

One good reason to collect long-term data, in my opinion is, again, so that you can establish a pattern, whatever it is, and then stand back and look at that pattern and say, "hmm, well what might that mean? What drives that pattern, what might change that pattern?" And then, if the pattern does change, you can say, "wow, the pattern's changed", as long as you have a baseline. Once you have a starting point, then you can say, "hmm, what I see this year is different than what I saw last year. There are more birds or fewer birds, at a particular time of year, of a particular species." And so, that is really interesting from a basic science point of view, from an ecology point of view, that is – what is that pattern, what drives that pattern? And those kinds of questions we ask in ecology all the time. But, those are also really, really interesting things from a natural resource management point of view. For instance, yesterday I got an email from somebody in the Department of Fish and Wildlife and they're doing a review of Marbled Murrelets, a species that's on the – listed on the endangered species list. And they wanted to know two things – one was what was the incidence of murrelets that we had actually seen, that is, what's the murrelet pattern that we've seen in COASST? But the other thing was, could we use a more common species that we see in the COASST data set Common murres, as a proxy for conditions that murrelets might face? So this guy who was contacting me already knew that our murrelet sightings are quite rare, and that makes sense, it's a rare bird. But he was sort of extending that thought and thinking, "well, hmm, but murrelets are little diving fishing birds, and what if we use a relative of murrelets, like larger diving fishing birds that are quite common up and down the coast, then we can actually use the COASST dataset and try and say something." So he was coming to us saying, "what do you think? Can we use the COASST dataset for this, and might we be able to design a retrospective study that looks back at when conditions are good and bad for murrelets, and might we be able to connect that to some sort of management strategy looking forward in the future?"

That's a good example of how COASST data are being used in resource management. And our data are used in all sorts of resource management. Certainly endangered species or threatened species kinds of things, but also disease sorts of things – when people should or shouldn't be in a particular location, what happens to those birds, our data are used a lot in fisheries management now, for all sorts of bycatch, but also our data are used to look at what's the advance of species into our region that might then be caught by fishers so that agencies might proactively be able to adjust bycatch limits, for instance. And I think that all of those things are really great, in fact since I've spent a lot of time in my non-dead bird life working on all of those issues, it's wonderful to see that the COASST data set can be and is being used for all those things. But, so here's the interesting thing. And that is that, for every single one of those things, the reason the COASST dataset can be used is because it's large. It's large in space and it's large in time. And if it wasn't, if it was just one beach, faithfully maintained by somebody, we wouldn't necessarily be able… we could use it for some things, but there are lots of things that we couldn't use it for. So the interesting thing is that an individual data collector, a COASST participant, can't actually hope to have his or her information as a single data stream used for any of those things all by themselves. But as a part of a larger effort they have every chance of having their data be used for all of those things. So it links them to resource management and conservation in a way that they couldn't do individually. And it allows them – if they know about it – it allows them to then have a voice. That is, they can go to a hearing about Marbled Murrelets, and resource management strategies and stand up and testify and say "I am a COASST participant and I help collect these data, this is what I want to do, and this is what I want to have happen." Not because of the individual data they collected, but because of all of the data that are collected in the program. So in a way it connects them to a greater whole, and more responsibility – it gives them a more responsible voice in conservation issues than they might have otherwise.

We have our very, very first ISE grant at the moment. It's a small grant, it'll probably last a little more than a year, to just conduct an evaluation of the program itself, which I'm finding quite interesting on several levels. Originally we had applied to ISE to take the COASST beached bird approach and apply it to other streams of data, so that a long-term goal you might imagine is a set of coastal communities all up and down the west coast within our geographic range, that each have people that are collecting different data streams but all in the same place. So you might meet somebody at a coffee house that was the marine mammal person or the marine debris person or the water chemistry person or any number of things that you could think about. And it might form in a – in some greater incarnation of the future – a whole new way that the community could talk with itself about what was going on. So that's a long-term vision, and… it's hard to know whether we'll get there. So here's a really odd thing I've discovered, and that is, the good thing about COASST is it's really big, and that gives us the ability to see a lot of things that are going on in the bird world, and thus in the near shore marine environmental health. The bad thing about COASST is that it's really big, and when you consider trying to start a new data stream, the activation cost of that seems to us at times almost overwhelmingly high. Trying to figure out how to get almost 800 people now[14] the opportunity to do some new data stream, and how we would work that up within the office, and how we would figure out how to pay for that – it's a little bit daunting. So that kind of stops us, I would say.

So here's the thing – this is my proselytizing thing, well, one of them. I think that you can use – in the strictest most, almost asocial way of thinking about science – I think that you can be that kind of scientist and really take advantage of citizen science. That is to say, you can look at a citizen science program and say, "Oh great, here's an opportunity for me to collect a lot more data or information than I could otherwise, and more or less for free. I mean I have to spend some time and energy doing this, but then all of these data collectors will be out there doing what I want, and I don't have to relate to them or interact with them, they're just sort of little robots out there." And certainly there are some people that are thinking about citizen science that way. I, certainly I think about it in part that way, but more often than not I think about it as a way to collect good quality data and in the process really connect with the people who are collecting the data, linked to a sense of place. Right, so why are they collecting the data? It's not because they're sitting around bored and they don't have anything else to do, in fact often they're retired, they have lots of choices of what to do. So they're choosing you and your program over some other programs because there's something about your program that speaks to them. And sometimes it's a taxonomic thing, like they love birds. But more often I think it's a place-based thing. Like, they love this particular beach that they're walking on, and they feel almost viscerally attached to it. They want to know what's going on, it's as if they see a place as a living thing, and they care about it. And when it changes in ways that they don't understand they worry about it. So if you can give them a way to help them understand in some ways what's going on in that place, they become also really attached to your program.

So that kind of attachment is something that we're not really used to thinking about in science. In a sense it's the attachment that we all have to our work, but within the people participating in my program, it's expressed a lot more openly. And what's really cool about that, I think, is the realization that it's not the birds, so much – it's the beach. And that means that it could be birds or it could be the cast-off carapaces of crabs, or it could be seaweed, it could be all of those different things. And as soon as I realized that, I thought, well gosh, that means there's a possibility, if I could figure out how to scale it, there's a possibility that people could collect – and not necessarily the same person

[14] In January of 2012, approximately 200 more participants than when we had spoken in January of 2011.

collecting all data streams – I don't think there's enough time in any person's life for that. But different people could collect all sorts of different information. And I've already watched COASSTers meet each other through the program, so they might have been neighbors in the sense of living in the same community for 50 years, but they meet each other through COASST, and they form these alliances of all different sorts, stretching from, "let's just go out and walk the beach together," to, "we've fallen in love, let's get married." And so I'm thinking, "wow, there's this incredible social fabric that can be woven in part through a citizen science program." And that – I think that that's just fantastic, and it means that there's a possibility that you can then weave science back and forth through that fabric, so individuals will call you up and say, "this thing is happening," or, "I'm worried about this," or, "what do you think about this?" or, "if you have a picture of this thing that I saw…" and give you information that you would never have before. And then you can give information back to them. And I see this potential future where science as it's practiced in universities or in agencies and citizens actually are a lot closer together. I think they're very far apart in general at the moment, and you know I'm a scientist, so that worries me. But wouldn't it be great if we had ways to bring those two cultures closer together in really affirming ways? That's why I lean towards that vision.

Science has, in my opinion, existed as a rich man's pursuit. So if we think of the scientist in the era of Darwin, for instance, who were those guys? They weren't first generation farmers' sons who had gone through a public school system and got into university on a scholarship, and worked to help put themselves through college. They were the sons of rich men, or rich families. And the whole construction of the university and how cloistered it is, and that it's this place where smart people can sit around and think, and that the way that we've conceived scientific society as these almost secret gatherings of people who have their own publications that only they know how to read because they're so full of jargon, all of these things, although they might be – they might have merit and value because they allow us to really dig into how to explain a piece of how the world works, they are also very good at holding us as sets of scientists apart from the rest of humanity. And, increasingly apart from each other. That is, if I walked into a convention of, I don't know the American Physics Society, would I be able to understand a single thing that they were talking about? Probably not. I think that to me the danger of that is that at the very time when I believe that we need science the most, because things are changing so rapidly, and we need to try to understand how things are changing and why things are changing, and we need to get in my opinion, not to sustainability, that is back to par, but beyond sustainability. That is how do we react to, adapt to, create things, be proactive, in order to look forward into this century with the hope of having things be better. I think the only way that we can do that is to involve many, many, many, many, many more people, and of course they're not all going to become scientists, so the only way to do that is to look at ourselves as a scientific community and say, "hmm, is it time for us to open the doors up? And if we do, what does that mean? If we let in everybody else, is that going to dilute us, is that a good thing or a bad thing?" I think that many, many scientists think about these things, maybe not explicitly, but certainly implicitly. Any academic that makes a decision to give a talk to any other group other than their own community, that is their own group of science and/or a talk at an academic institution or a scientific society, you know if they venture beyond that in any way, they're taking that first step. They're making a decision, "hmm, maybe it's worth it for other people in the world to know what I do." And I think that's happening in lots of ways. So citizen science is one expression of that, but a totally different way of connecting to the public is one-way communication, right? That is, I stand up and I give a speech and it's heard by a lot of people. So the TED talks, for instance, are a really good example of that. And because they're on the web, lots of people can see them, even if they don't go to the original TED talk. So TED talks obviously are many more people than scientists, but it's a way for science to get out there more and the people who run the TED talks coach all the people that are giving talks, so that the talks that they give are largely jargon-free. That is, they are adapted specifically for a larger – intelligent, but larger public. And so there's another way that science is getting out there and starting to connect. And a hundred years from now, if we don't do that, I think that the swell of humanity that's non-science will just simply overwhelm science. And we'll be more imploded than we are now, and I just don't want to see that happen.

When I started all of this, I was frustrated with only being on one seabird colony and knowing a lot about it, and wondering whether what I was finding was typical of all of the colonies in my region of the coast, or whether it was - my data were idiosyncratic. I was trying to figure a way out of that that was doable, and I settled on beach bird monitoring as a possibility. My original thought was that we might be able to, if we worked really hard, get to somewhere between 30 and 50 people working with us, and I selected one portion of the outer coast of Washington State to focus on – for two reasons – one is that the south outer portion of the coast of Washington State is relatively more populated than the north part – the north part being a collection of National Park and tribal reservations, and the south part being dotted with at least a few little towns. And also the south part is closer to the Columbia River which is the border between Washington and Oregon, and there's some really interesting oceanographic effects that happen where that river meets the sea, and I was interested – I thought that they might actually produce some interesting patterns in the birds that are washing up on the beach. And I didn't actually – I can't remember that I had a particular thought about how long I wanted it to last, I just thought - ok, I want to try this out and see if it can be used as another way of getting data on the species that I'm working on on the colony, and whether those patterns might fit together. And like many things, when it started it just took on a life of its own, and pretty soon I sort of turned around and it was much bigger than I thought it would ever be, and in that way COASST is a little bit like a forest fire. Not that it goes quickly, it's like a really slow-moving forest fire. But it's inexorable in that sense. And now, I mean now it's really large, and there are lots of people involved, and in that sense I am – I guess I would say I'm a happy prisoner. That is, it's hard for me to imagine walking away from COASST, just because there are so many people that are involved and communicating with us on a daily basis, and very interested in what they're finding, and extremely interested in seeing the larger patterns and being able to say something about what's going on in their environment. And it seems – maybe this is arrogant on my part but it seems almost reprehensible to walk away from all of that public enthusiasm and desire to participate. So that's the prisoner part. But the happy part is I like it. So, it's ok, so far.

I would say in a sense COASST has made me grow up in a direction I hadn't anticipated, by really realizing that learning is lifelong and that it's not just about the data. Which is something I think that a lot of scientists don't know. It's about people. And in a scientific community, especially an academic one, you're surrounded all the time, all day, by people who are like you, or the students. And within the students there are a lot of bright, shiny faces that can convince you after a while that you're the font of all knowledge, and that's really dangerous, because in the real world, scientists are in a vast minority, and in an irrelevant corner of the world – we're not the world leaders, we don't make big decisions in politics or in corporations. We can jump up and down at our own scientific meetings, surrounded by ourselves, preaching to the converted and talk about how central science is to humanity, but honestly other than in ways that we can take it and make it commercially viable, science isn't very relevant to society. And I think that one of the reasons is because we insulate ourselves so well from society by convincing ourselves that without a higher degree, you can't really talk to people who are as smart as we are. That's a really, really dangerous thing. COASST made me open my eyes and see that reality, and decide that I could be part of the scientific community, but also be part of a larger community, and be just as comfortable talking to somebody about how to identify some rare bird or what happened to it, or the natural history of the conservation of it, as I was having a conversation about what else they found on the beach or what their grandkids are doing, or what car they bought, or any of the myriad of normal things that normal people talk about. And all of that made me realize that if we really want to see science continue through this century as a set of independent inquiries, which is kind of what science is, then we had to involve many, many more people. And not by training them to be exact versions of us, but by giving them reasons to see why science is relevant in their lives and their communities. COASST does that in a really small way, we're one very, very small part of what I hope will become a very large movement to make science relevant.

Terry L. Root
Stanford University

Pushing the edge of science forward

Unlike the other scientists I spoke with, Terry's work in citizen science has been all with the data and not with participants or project design. Terry was a pioneer in using Christmas Bird Count data, an unconventional choice for a graduate student in the 1980s. Even so, Terry talks as if other career choices were far more risky, including interdisciplinary research and advancing awareness about climate change. In an ancillary conversation, Terry suggested that her penchant for looking at large-scale trends may have come from flying with her pilot father, watching the world go by below her – an insight that I'm sorry did not make it into this profile.

I am an ecologist that looks at the world on a very broad scale. In order to do that you have to use other peoples' data, and finding other peoples' data that are scattered around a continent and in enough locations that you can actually draw conclusions is impossible unless you use citizen science. Basically I wouldn't be where I am now, at all, if there wasn't citizen science. I wouldn't be doing the work I'm doing at a University. I probably wouldn't be a faculty member.

My first encounter with volunteer data, I was working for JPL, Jet Propulsion Laboratory at the University of Colorado. I could take a class for free, and so I took a biology class. And in that class, I had to do a project, and at the time I was a scientific programmer, and a professor, Carl Bock, had Christmas Bird Count data from the National Audubon Society on a computer tape, and he basically did not know how to program a computer to retrieve the data. He wasn't a computer person. I was, so I volunteered to use those data or some of those data for my project. That was the first time that I used them. And that's primarily the type of data that I've used, Christmas Bird Count data. The project that I did ended up being published in American Midland Naturalist[1]. That was probably in 1985.

I enjoyed biology a lot. I decided to quit my job, and I went and I worked with Carl Bock on a master's degree. For the master's degree I was looking for bio-geographic boundaries of birds and seeing where they were. Then I went on for my PhD at Princeton, and it was then that I did the book, the North American Winter Atlas of Birds

[1] Root, T. L., M. A. Holmgren, and R. W. Andrews. 1981. Winter Abundance Patterns of Some Songbirds near the 100th Meridian in the Southern United States. The Southwestern Naturalist **26**:95-100. See also: Bock, C. E. and T. L. Root. 1981. Winter abundance patterns of landbirds in the United States and southern Canada. American Birds **35**:891-897.

that was published by Chicago Press[2]. And then I switched over and I was working on my dissertation using the Audubon data, and looking to see what was limiting the edges of species ranges.

When I first started using these data for that project, I was only looking at the area around the 100th meridian, and seeing that the 100th meridian was a very strong barrier for birds. The eastern species came up to it and the western species then started there. But there are no mountains there, there's no rivers there, there's no anything there, so what was the magic thing about the 100th meridian? So I started working at that scale. For my master's degree I think I worked on the eastern half of the United States, and then for my PhD I looked at the entire continent. So I just kept getting bigger in scale, looking at what was there.

And so I was looking at the northern and the eastern and the western range edges of different species and a very strong pattern came out for the birds' northern ranges. I found that there was a very large percentage of passerine species (and I think non-passerines but I didn't really quantify it) having their range edges being along a certain thermocline, and so that made me think that it had something to do with the temperature being, or getting, too cold. The way birds survive the nights is that they feed all day and they put on fat, and then in the evening, and through the night, what they do is that they shiver to stay warm. And they wake up the next morning skinny again, and they go out and they feed and the whole process goes on and on. So what's limiting species in the north has to do with both the length of day and how cold it gets at night. They have to have a length of day long enough to be able to put on enough fat to survive the cold at night. And what I found was that temperature was strongly related. And then I wanted to figure out how that all worked physiologically, so then I broke away from using the citizen science and looked at the actual eco-physiology of the species in the field, and published a paper on that too[3]. Those were my main uses of the Christmas Bird Count data.

Carl had published quite a lot on these data, and he knew that there were some…. what's the right word? He had checked the data to see how reliable they were. And the way to do that was to look at data that other people had collected. What we found was that you can't use the data for very gregarious species because it's too hard for volunteers – it's even too hard for professionals – to count a large number of individuals, like 200,000.

[2] Root, T. 1988. Atlas of Wintering North American Birds: An Analysis of Christmas Bird Count Data. University of Chicago Press, Chicago, IL.
[3] Root, T. 1988. Energy Constraints on Avian Distributions and Abundances. Ecology **69**:330-339.

You just can't do it. You need to have a special way to do it. So, gregarious species were out[4].

And then the other thing is rare species. Christmas Bird Count data are competitive, and so people like to see as many species as they can, and so often times they will mistakenly count things that may not actually be the particular bird that they were looking at. So for instance, when I plotted out all of the information I had on peregrine falcons, the map basically was a uni-layer across most of the continent, even where peregrines may not occur. Everybody wanted to see one. And so there was always, well it wasn't always, but in many of the count locations they would count seeing one, and when you looked at the map you knew that that wasn't correct. So you have to not use the data to look at rare species and you just avoid gregarious species.

Carl and I also looked at turkey vultures, which had then been extensively examined by the Air Force, because turkey vultures often times will fly at the same altitudes that their jets are flying. They're very concerned about turkey vultures going into the jet engines, so they've done a lot of work turkey vulture presence and density. And the data matched very nicely for that[5]. Another way we looked at it, we looked at waterfowl that had been counted by Fish and Wildlife specialists, and compared the data to the Christmas Bird Count data and found that they were well represented. So, that then told me that I could look at not the rare, and not the gregarious, but everything else.

Choosing to work with Christmas Bird Count data was a risk. But I think that it was seen as a bigger risk by the professors at Princeton than I thought it was, because I'd already published on the data. I already knew the data were well received, and I already knew that there were patterns in the data that I wanted to explain. So, you know, that's kind of what I did. I just didn't worry – maybe foolishly I didn't worry about it – I just felt (and still feel) that the data are reliable and that everything would be fine. And that I could push the edge of science forward by looking at a scale that other people weren't looking at very much. So I just jumped in and went from there.

I didn't have any challenges for publishing. Where I did have challenges was not long before my dissertation defense. One of the members of my committee was very concerned about the fact that I hadn't collected my own data. And there was nothing I could do, all I could do was say what I just said about how it had been quantified and shown that the data for the species I examined are correct. But, I still hadn't collected my own data. He was concerned about that. He was worried about the quality of the data, that the data may not be good enough to draw robust conclusions from. His opinion was

[4] Bock, C. E. and T. L. Root. 1981. The Christmas Bird Count and Avian Ecology. Pages 17-23 in: Ralph, C. J. and M. Scott (Eds). Estimating Numbers of Terrestrial Birds. Studies in Avian Biology **6**: Cooper Ornithological Society.
[5] Ibid.

that the only data that you can do that from are data that you've collected yourself, and you know that you've collected it well. He agreed to go off of my committee, and I put on another faculty member.

Carl Bock probably got most of the heat about things like that because he was the first to get the data computerized and to publish extensively using these data, and since I was publishing with him to begin with, he was backing my reputation. The paper we published in American Midland Naturalist demonstrated that people felt the data were scientifically sound. And so when I started publishing, my book[6], the Ecology paper[7] and the Biogeography paper[8] all came out in 1988, and I think it was just understood by then that with the data, you could draw conclusions from it but you had to be careful. So I didn't have any people saying, "no you can't publish this," or, "we won't review this because you used somebody else's data."

I think Christmas Bird Count data were one of the catalysts that changed folks to start looking at a large, very large scale. When I did my work, and when it all came out in '88, I was one of a very small handful of people that were looking at ecological processes at a large scale. Very, very few of us were doing it. And I think that as my work came out, and the work of other people who were working at that scale, when their work started coming out, everybody got excited about it. And it really did make a difference I think. I think having data that were collected on a continent-wide scale, which by necessity means that it has to be collected by professionals and non-professionals alike, that were used to uncover important ecological and physiological findings, showed the absolute necessity of citizen science. I helped to show that the data were indeed...., basically, I was able to use the data and find very important ecological findings and physiological findings and people then were more satisfied that that was something that was, that could be done. That the data were indeed usable, they weren't just crummy data. So I think that by doing my research at a large scale and showing and doing things in a robust manner, it got other scientists to realize that they could use other's people data, too, and do the same type of thing.

My approach to working with the data hasn't really evolved at all. My bachelor's degree is in math and statistics, and so my first jobs were being scientific programmers. I was working on the cosmic ray experiments on the Voyager spacecrafts that went to Jupiter and Saturn and Uranus, so we had a very, very, very large amount of data. There were just astronomical amounts of data. So I had basically learned how to deal with data by

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[6] Root, T. 1988. Atlas of Wintering North American Birds: An Analysis of Christmas Bird Count Data. University of Chicago Press, Chicago, IL

[7] Root, T. 1988. Energy Constraints on Avian Distributions and Abundances. Ecology **69**:330-339.

[8] Root, T. 1988. Environmental factors associated with avian distributional limits. Journal of Biogeography **15**:489-505.

having to deal with the cosmic ray data. And I don't think that there's anything that you really do differently with volunteer collected data or scientifically collected data.

In the book what I did do was I plotted out all of the information and if somebody said they saw a Prothonotary warbler, which is an eastern species, in Washington State, I would drop it, and I would not include it. I knew enough about where the birds should be in the wintertime, and what they should be doing, that if there was something that was absolutely, obviously an outlier, I eliminated the data and didn't use it.

I'd been on Christmas Bird Counts myself several times, before doing this work. My great aunt and uncle were birdwatchers, and they got my mother into being a birdwatcher. When we would go places she would always make comments about birds, and we would stop and see birds. When I was about eight years old, we were in Florida and I can remember stopping the middle of a rainstorm looking at the spoonbills in a tree, these beautiful pink birds in this real dark tree. That's my first real memory of bird watching.

But then when I was about 14 we went down to southeastern Arizona at Thanksgiving. My mom was trying to get dinner ready and I was basically in her way, instead of helping, because the kitchen was so small. And so she said, "just take the binoculars and go out and look for birds." Out I went, and I was able to identify two species by myself, and that basically was what started me bird watching.

My first Christmas Bird Count I did was with my mom, I don't actually remember when it was, but I've been on several. Mom was very active in the Audubon Society in New Mexico, and I would always go out and help her on the Christmas Counts. There was one in Socorro, one in Albuquerque, and one in the Sandia Mountains. I would try to do at least one, and oftentimes all three of them. I basically stopped doing them when I got into graduate school, because it just takes a lot of time.

In the 1980s, the focus of the Princeton Biology Department was on basic science. I was told that I was the first person they accepted into the Ecology and Evolution Program who said that they did not want to go into academics. I wanted to go back into business, because I felt as though being in business I could make more of a difference than I could in academics. And yet, I'm one of the only ones in my cohort that ended up getting an academic position. So that tells you what you know (laughing). But, a job came available at the University of Michigan that was for a conservation scientist. And if you're working on conservation issues you're working on helping to solve real world problems, and so I applied and I got the job. I just went for it. If I hadn't have gotten the job, I probably would have gone into industry.

When I was hired at the University of Michigan, I was told that a stipulation of my being hired was I would go out in the field, to learn how to advise students when they were going in the field, because that's primarily what a lot of the students were doing and I needed to know how to advise them. So that was one of the reasons that I did field work. Basically I was in the field for four years, and I fulfilled my understanding of what it's like to be in the field, so I could advise students during their field work. During my field work I got very frustrated, you would get two data points in a twenty four hour period, and that just was driving me nuts.

In the mid '80s there was a paper that was published by Peter Kareiva[9] and others, that was looking at the size of the study area for researchers, and he came out and said that a vast majority of ecological study areas were roughly the size of a tennis court. When you're looking at species at that small of a scale, you're not going to be able to see things that you can see if you're looking at a broad scale. And if you're looking at a broad scale, you can't see things that are happening on a local scale. I strongly believed that these two types of studies were very complementary. But at the time, because so many people were working on species at a small scale, the belief was that competition and interaction between species was really what was the primary shaper of species distributions or ranges. It was a very commonly held idea because there just weren't that many studies that had been looking at the large scale, and looking at the large scale you really can't understand – well you can, but it's not easy – the biotic interactions that are going on at the local level. But you can see how temperature and precipitation and soils and topography and that type of thing, how all of those are shaping species ranges. In the mid to late 80s there weren't that many studies that were actually looking at species ecology at a scale that was larger than, well, certainly not larger than a state. There were certainly some biogeographers, but most of the biogeographers were in geography departments, not in biology departments. The person that was contrary to that was a man named Jim Brown, who is at the University of New Mexico, and he was looking at things that were at a much broader scale. But he and I were pretty much the only ones at the time, except for those who were in geography departments.

Well, what I did for my fieldwork at Michigan was I wanted to figure out what the mechanism was, in the species, that was causing them to have their ranges limited by temperature. It had to somehow involve their physiology. So I picked four species that had maps in the winter time that showed that the edges of their ranges occurred at

[9] For perhaps the first introduction of this point, see Kareiva, P. and M. Anderson. 1988. Spatial Aspects of Species Interactions: the Wedding of Models and Experiments. Chapter 4 (pp. 35-50) in Hastings, A., ed., Community Ecology: A Workshop held at Davis, CA, April 1986. Volume 77 in the series, Lecture Notes in Biomathematics, S. Levin, editor. Springer-Verlag, Berlin, Germany. In regard to a graph comparing plot diameter and number of replicates across experiments published in the journal *Ecology*, the authors comment, "The point is that replication and scale require money and personpower beyond the means of most ecologists." Instead of calling for citizen science, these authors call for theory and modeling.

particular places[10], and then I went and did a transect study from north to south looking at the temperature interactions with fat levels and with the metabolism of the four species. Basically the work at a large scale had prompted me to do work at a smaller scale to see how and why the patterns seen at the larger scale actually worked. And if I continued on with that line of work, I would have taken what I found at the smaller scale and translated it for the larger scale to see how well it actually did explain the patterns, then gone back down to the smaller scale and looked at how muscles work, and things like that. Which I didn't do, primarily because I don't like doing field work. I really don't like doing things at a small scale, I really like doing things at a large scale. And I just felt like my passion was more on large-scale patterns than small-scaled ones. I felt as though I could make a larger contribution by following my passion and letting other scientists who read my work follow up by studying the birds on smaller scales.

My husband and I wrote a paper together in 1995 that discussed strategic cyclical scaling, SCS[11]. What that paper says is that work at a large scale tells you what to look at at a small scale, and then you do the work at the small scale and then you can go back up again and see how well the work you did at the small scale is influencing what's going on at the large scale. So by cycling back and forth between the small scale and the big scale we are better able to understand a system in its entirety. You can't just do one or the other. Looking at only one system provides only part of a picture. "Strategic" is in the title because what's important is the answers that managers need, the information that managers need to help them solve some problems. That was our way of saying that research can and must be used to help solve real world problems. Academics can't only be in an Ivory Tower any more. We need to be choosing what we look at based on what is needed in the world because there's so many real world problems now that there's a lot of research questions out there that you can ask that has to do specifically with real world problems. We were advocating in that paper to not shy away from such problems.

When you're doing conservation biology you're doing biology that is focused at a problem. A problem in the world. And that meant specifically that the work that you're doing could be and would be applied to a specific problem. Basically in conservation biology you're doing what you need to do not for basic research but for applied research. And that to me is much more appealing. Conservation biology can be viewed as a crisis science. It can be reactive, working on a present-day problem. Or it can be proactive, working on avoiding a possible future problem, but in general it still has the aspect that it's used in a very different way than basic biology research is used. You actually are trying to solve a real world problem.

[10] In review of the profile, Terry clarifies, "species with winter range limits that were coincident with isoclines, a particular temperature."

[11] Root, T. L. and S. H. Schneider. Ecology and Climate: Research Strategies and Implications. *Science*. **269**(5222):334-341.

I personally do not enjoy doing research for research sake. There are so many problems in the world that need to be addressed that I just can't focus on research for its own sake. And, applied research normally requires work by interdisciplinary teams, which is always a challenge. I didn't tell people at Princeton that I wanted to work on applied research, of course. I just told them that I was working on large-scale eco-physiology. Which I was. But there was a direct linkage to climate change. And it doesn't do too much good to work on climate change if you're not getting it out to managers or decision makers and helping them understand what works and what doesn't work, what's true and what's not true.

If you're going to work on real world problems you've got to be working with other people because there's more aspects to a problem than just one. You have to be getting many more views of things. And so that's what I did, I ventured out into interdisciplinary work. Doing interdisciplinary studies means that you're often reaching outside of what your normal comfort zone is. So you're working with other people on things that you often don't really have that good of a grasp on. I worked with a climatologist, Stephen Schneider, who became my husband. He and I were able to put our studies together because he was working on a continent-wide scale of course, and I was too. We were able to put things together, and both of us became more interdisciplinary. He learned the biology and I learned the climate. But it's a risky thing to do because it's pulling you away from what you normally do.

Another thing that's tough is that if you're working on real world problems you need to get the information out to the public. We can all be sitting in our Ivory Towers and doing as much applied science as we want, but it's not going to change the world unless you get it out to the public. And it's very important to have the public understand, which often means you are having to condense, abbreviate, use metaphors and the like, which can make your colleagues uncomfortable and even upset. But when I got on the scene, making science accessible to non-scientists was no longer seen as a negative to interact with the public, but it was certainly not seen as a positive. I think it was more of a neutral situation. But it could easily end up being "careericide[12]" because if you say something, if you simplify it so much that it loses its oompf, your colleagues can get very upset with you because you forgot this caveat or you forgot that caveat and it turns out you may not have forgotten them, you may just have not been quoted right or you had to simplify things more than you would have liked.

A real world problem that I think is a huge issue is climate change. People may not be worried about the temperature getting warmer, but if they find out that the such-and-such bird isn't going to be at their feeder any more, or they're going to have other birds at feeders that are not normally there, people sit up and take note. I think that was one of

[12] Root, T. L. 1994. Scientific/Philosophical Challenges of Global Change Research: A Case Study of Climatic Changes on Birds. *Proceedings of the American Philosophical Society*. **138**(3):377-384.

the reasons that my 2003 paper made such a splash according to the reporter whose story about the work was on the front page of the New York Times. He said that they had never had an article on plants and animals and climate change. And there were two of us that published in the exact same journal and found the same types of information, and plus no other news was going on that day, so he got to put it in on the front page.

I think scientists realized that climate change was a real issue and that it could be absolutely devastating to biodiversity, and the only way that we were going to be able to change things would be to get voters to vote people in to office who understand that climate change is a big issue. And to do that you have to have people vote. Actually, many in the government were very interested in what we were doing, and they requested that we testify before Congress. It can be very exciting when you may be directly influencing policy. Plus I was at the University of Michigan, working as a conservation biologist, and that was my job. Conservation biology is a very unusual sub discipline or discipline, whichever way you want to put it, because you work on real world problems and you need to get the information out to the public.

I've testified in front of Barbara Boxer's committee in Congress. Before that, I spent a lot of time with a man from an NGO, trying to put the information from the Third Assessment Report of the IPCC[13] into some kind of capsule that the public and reporters could understand. We did it with a thermometer, and had writing to the right of the thermometer, so if you we get to a certain degree, these events or catastrophes could likely happen, if you go to this degree you have these catastrophes. We just put it all on one page, and I passed it out to the people at the Congressional testimony, and Barbara Boxer held it up and was very supportive of that. That wasn't science, that was communicating science to the policy makers in a manner in which they could understand. It was very well received. The other people who were on the board that were testifying, I believe were quite taken by the fact that you can simplify things down in a way that didn't compromise the whole understanding of the science, and still get the ideas across. That's one instance of communicating science to policy makers that I remember very vividly.

The primary way that I have worked towards influencing public engagement and education is by encouraging students to not be hesitant to use data that have been collected by citizens. Having them understand that the data have to be ground-truthed in a way that you can figure out what you can use and what you can't use. I had a student, Jeff Price, who looked at the Breeding Bird Survey data, and did a summer atlas very similar to the one that I did for winter. He still uses citizen-collected data. There's a post-doc, Scott Laurie, here at Stanford, actually he's at Carnegie on the Stanford campus, who is very much into citizen science and he's been trying to work on a website, iNaturalist,

[13] Intergovernmental Panel for Climate Change. See http://www.grida.no/publications/other/ipcc_tar/

that is more user friendly for entering bird data than eBird[14] is. Scott is really excited about getting his program, or website, known by as many amateur and professional naturalists as he can. I've been encouraging him a lot. When I give talks, people will always come up to me afterwards and say that they didn't realize that data like that could be used, and so then students get involved with using other peoples' data.

In Jeff Price's situation, the student working with the Breeding Birds census data, there aren't any other data like those that are available. And I actually think that's the bottom line with a lot of citizen science data is that you have to have fairly large-scale data, and you're not gonna be able to get it any other way so you might as well use what you've got. And I think it's a very important thing to use, so that was why I pushed Jeff to do his work. In addition, the Breeding Birds Surveys are more rigorously conducted than the Christmas Bird Count data. A lot of people don't see these data as being collected by citizen scientists because of how rigorously it is collected, but – well, I certainly think they are. Anyway, they're collected very rigorously, and so the data – given what they are – can tell you an awful lot that other data can't.

Now on the other hand, I see citizen science as being a way to get people involved with the environment and understanding how important the environment is. One of the ways that people take ownership of something is by being part of it. We need the public to understand that there's a significant problem in climate change, and the more people we can get working on aspects of nature, the better. That way they have ownership, and as the globe warms, for example, they'll realize that could damage things they value, leading them to support necessary changes. In my particular case, how the birds were using the environment itself and how that could change with rapid climate change.

When I wrote the Atlas, what I had hoped that it would do – which it didn't – was that it would engage the everyday people in the United States to understand that you can use the data that they collect at Christmastime to help tell us where birds actually occur in the winter. , That could tell folks where they might be able to go and see certain birds in the wintertime. So the book would be used by the public to help people figure out if they want to go to see a particular bird, that the best place to do that is at a particular place on the Missouri River, for example. What I was trying to do was take the data that people had collected and get it back to those people, so that they could use it to actually understand what was going on with the species in the wintertime.

I thought that the book would sell a lot better than it did, and it didn't. I think part of it was that it wasn't marketed well, perhaps there was not the demand out there by people to figure out where the winter distributions of certain birds were because the field guides have winter maps in them anyway. And even thought they weren't as good a

[14] Terry clarifies, in review, "eBird is a website where citizens enter their bird observations from around the world." See www.ebird.org.

resolution, that's what they used instead of using the Atlas that I did. At least that's how I understand it. It seemed to be used by a lot of professional ornithologists, but I am not sure how they used it. lot of libraries bought it and a lot of ornithologists did, and I don't think very many other people did.

But that's something that iNaturalist does now. You can come up with a species list for a particular place that you're going. So you can say "I'm gonna go to this latitude/longitude. What's been seen there?" That way you will already have a species list so that you know what to be looking for. Another instance is, there's a species list at a particular park, and it includes a species, but that species has never been recorded there on iNaturalist. That's an added impetus to the people who are putting in data for iNaturalist to actually go and try and find those particular species that haven't been recorded in the program before. In some situations the experts can come in and say, "well it hasn't been located because it's really not there," so it was just a mistake in how people thought of it to begin with. iNaturalist is set up in a very, very rigorous, very scientific manner, to capture the data in a lot of ways.

You use iNaturalist on an iPhone. What you do is, you take a picture of whatever you're looking at, and that goes up on the Web. And if you don't know what it is, then you ask people you know, "what is this?" And then the experts that use iNaturalist will be involved and tell you what it is – it has to be vetted by an expert or two – I'm not really sure how many experts – who say that it is indeed what it is. When the data are put in, they're put in in a scientific manner, so the latitude and longitude is put in, the sighting is put in. It doesn't have abundance data – it doesn't do abundance data very well yet, I'm not sure how recording density could be done.

iNaturalist, I think, is exceedingly important because of the way that Scott has set it up. The data that do get entered are robust enough that they are usable, and I think they'll be usable for time immemorial. And we need to make sure that data like that are collected. There's no other data that are collected in that manner. eBird, for instance, is a repository for data collected by people who have seen different species of birds. iNaturalist is not limited to birds alone. eBird, iNaturalist, and the Christmas Bird Count data are all screened. What gets put in is high-quality data, and so it's usable. You have to realize that some of it may not be usable, but most of it can be.

I think iNaturalist is taking advantage of the social networking skills that people have, or desires that they have, and I think that's going to help citizen science in a lot of different manners. It will get people more interested – certainly a younger generation which Audubon just isn't capturing yet, and they need to do that in some manner. I think that the stuff that Scott's doing is working so well because he is taking advantage of social networking on the computer.

I've been trying to push iNaturalist forward in order to get it funded. I've gotten Scott Loarie involved with different entrepreneurs to try and get money for him, I've contacted people at Cornell for him, to try and get him to get connected with Cornell, so I've done a lot. I work with Scott quite frequently. I really think that what Scott is doing is exactly what we need. I think we need to have social networking involved and we need to make sure that the data are collected in a manner that are usable, instead of just making people feel good. We need to make sure that the data are there.

I think that what I have done, is made people understand that citizen science data can be used, and that they are valuable. At least I hope that's what I've done, I feel as though I've done that. I'm sure there's always going to be people who say if you don't collect your own data you may be mislead. But I just don't agree with that, and I think that by using the data you can show you get cohesive information from citizen-collected data. I think I have shown that with my research. Actually what I hope I have done is helped people to understand how important the data are, and how important scientifically they are, and that they can indeed be used in various scientific manners. At least I believe that is what I have done.

I actually don't care what kind of citizen science it is, if it's. If it's getting people involved, that in itself is important. Certainly you try to make sure that the data are collected in manners that you can use it. I'm sure there's some citizen science work out there that has not been usable because the data just were not good enough. But still, even if the Christmas Bird Count data were not scientifically sound, the number of people that that particular bird count has gotten into biology or into environmental issues would be enough of a reason to have the Christmas Bird Count data. It's quite amazing to talk to people and find out that one of their first interactions with science and the like has been through Christmas Bird Counts. And they felt an ownership with those data, without that I don't think we would have as many people turned on to the environment as we do. So there are other good things that come out of citizen science other than just data.

Candie Wilderman
Dickinson College

Scientifically telling local stories

As a native Pennsylvanian, I had heard about ALLARM during its early days, although never in much detail. I encountered the project again as an undergraduate research assistant at Hudsonia, Ltd., through ALLARM's newsletters in the library. I was pleased to finally meet and work with Candie, first through the 2007 Citizen Science Toolkit Conference, and more intensively through the Public Participation in Scientific Research inquiry report for the Center for the Advancement of Informal Science Education. Candie was one of the first to publish typologies for community science, the term she uses to describe her volunteer water quality monitoring initiatives. Her own project has transitioned from a "top down" to a "bottom up" approach over its life-cycle. Regardless of the project approach, she has described a "three-legged" stool analogy for attributes that vary across projects, with the legs being research findings, science education, and community action.

I'm the founder of a group called the Alliance for Aquatic Resource Monitoring, the acronym is ALLARM[1]. We're a project of the Environmental Studies Department at Dickinson College. We provide technical and programmatic support to watershed associations in Pennsylvania who have concerns related to water issues. That might be water quality, water quantity, land use, concerns in their watershed – they have questions, and they feel that collecting data will help them answer those questions. So what we do is we provide support for them to help them reach their goals and answer the questions they may have.

I started the organization in 1986, when I was a faculty member at Dickinson in the Environmental Studies Department. We had a state legislator, John Broujos, from the Carlisle area where I working, who was very interested in passing an acid deposition control act in the Pennsylvania State Legislature. He felt that he knew that Pennsylvania received the most acidic deposition of any state in the nation and he was very concerned about it. He had seen the impacts and he thought that at that point in time – that was before the Clean Air Act controlled the precursors for acid rain – he felt that if Pennsylvania could pass an Act, given that we're a coal state and we produce an awful lot of these precursors, that that would be a model for the nation, and he was very, very interested in doing that. When he started talking about this Act, he discovered that very few people in his constituency had any idea whatsoever what acid rain was, so the people were very ill-informed about this problem. He got this idea that people should be out there monitoring streams and seeing for themselves what's going on with acid rain.

[1] http://www.dickinson.edu/allarm

So he called together a group of scientists, and I was one of the people that he called to the table. There were about five of us, and he asked, "can we do this, could we go out and could we actually monitor for the impacts of acid rain in streams all over Pennsylvania?" And everybody at the table said, "no, you can't do that, you need trained personnel in order to collect samples, and blah, blah, blah, blah, blah, blah," and we all left the room thinking, "great idea, but not practical, not realistic, it's never going to happen."

But, I started mulling it over in my head, and started thinking, "well, you know, why couldn't we do this?" Really, to measure for impacts of acid deposition there's a couple of parameters that are fairly easily measured in the field by amateurs – pH and alkalinity – and if nothing else it would just be a great educational tool. I mean, I didn't think we'd really collect much interesting data but we would make people more aware of the issue and it would be good, educationally. So I started thinking positively about this, and I had a student that I was working with and I shared it with her and she was just like, "let's do it!" I said, "well, we could try, we could throw it out there and see if anybody's interested in it." We got the idea that this might be a good public educational tool, for a very, very important cause.

The way we started was we published an article in a Pennsylvania-wide magazine called *The Pennsylvania Angler*, which is a fishing magazine. We decided to call it the Alliance for Acid Rain Monitoring, and we talked about it like it was actually an organization that provided support for people who were going out and monitoring streams, but in fact we didn't actually have any volunteers – at that point in time it was really just our vision. That was published, and the next day we got about fifty phone calls. And they were like, "I want to join, I want to join, I want to join! I'm sick and tired of writing letters, and sending money, I want to contribute to a database." We were a little surprised that there were so many people who were in touch with the idea that gathering scientific data was a really important way to contribute to solving a problem, and that at this point in time the documentation of the problem was really critical.

So we started working with these people. We started developing protocols, and finding the appropriate field equipment, and we started holding training sessions, again, always keeping in mind that this was primarily an educational project and that we were still very uncertain about the quality of the data that we were going to be able to collect. We weren't really sure at all how we were going to use the data, so it was a little bit naïve at that point in time. In any case, the data started coming in from many, many volunteers, and they kept growing and growing and growing, sending in data – we had been collecting weekly. And after about two months it of course occurred to us that, wow, not only might this be good educationally, but this is really interesting data. We were starting to see patterns, we realized that we were catching what they call acid episodes, which are short-lived episodes in the stream that you might not catch unless you just happen to be out there every week measuring pH and alkalinity. And we started getting very, very excited about the data and started shifting some of our focus on to data management, data interpretation, and a little more sophisticated science education for the volunteers. So that was how it started. Because it was an early program, we didn't really start it within the context of citizen science or community science or whatever. We were sort of just out there, on a limb [laughing].

It was also very interesting because, coming from academia, it was very difficult to convince my dean that this was scholarly work. Or that this was something appropriate for a scientist to be doing. At that time I had just finished my PhD dissertation, which was on diatoms as water quality indicators[2], and I was doing some publishing in the diatom literature. My dean very clearly said to me, "well, this ALLARM stuff is interesting, but it's service work, it's extra curricular, you'd better keep publishing about diatoms." And I thought, "you know, five people are reading these articles about diatoms and they don't even understand it, why am I … [laughing]?" I just didn't feel like this was what I wanted to do with my time. And so I just decided I was going to pretty much shift my scholarly activity into ALLARM, which I did, and ultimately the college was convinced.

I'm not part of a research university – I do not think that if I was part of a research university that I would have been able to maintain my position there and continue having my primary scholarly activity be working on community based research and community science – at that point in time. It may be different now. However, because Dickinson is a liberal arts school, they do recognize the variety of scholarship that people can engage in that is meaningful. And they don't only require publications in peer-reviewed journals, although they much prefer that. So for example, artists can have art shows that are peer reviewed, or acceptance of their work in places that are peer reviewed. And I was producing a tremendous amount of reports and scholarly analysis of the data, presenting this at scientific conferences and things like this, and I did a little bit of publication. I was short on the peer reviewed scientific publication because it's not the kind of stuff at that point in time that got published in those kinds of journals, because it was volunteer collected data. But I was long on the peer review from conferences[3], and in-house publications[4] that we had to constantly reprint because there was so much demand for them, and things like that.

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[2] Wilderman, C. C. (1987). Patterns of distribution of diatom assemblages along environmental gradients in the Severn River estuary, Chesapeake Bay, Maryland. *Journal of phycology*, *23*(1), 209-217.

[3] See, for example: Wilderman, C. C. (1990). Patterns of variation of pH and alkalinity in Pennsylvania streams, based on data obtained by the Alliance of Acid Rain Monitoring (ALLARM), a citizens' monitoring program. In *Proceedings of the Conference on Atmospheric Deposition in Pennsylvania: A Critical Assessment* (pp. 94-95).

[4] For a current set of resources, see: http://www.dickinson.edu/info/20173/alliance_for_aquatic_resource_monitoring_allarm/1532/technical_assistance/2 As well as:

The other thing that started to happen is that, because I was out in the community so much, Dickinson College started to get sort of a reputation for doing community work, which it had never had before. It always had the reputation of being very insular, and very Ivory Tower. And so the administration – the Dean and the President and so on – were hearing from people in the community when they would go out. They'd say, "oh yeah, do you know Candie Wilderman, and ALLARM?" They were hearing a lot about this, and they were saying, "oh my gosh, there's some benefits to the University or to the College in regards to this project." And, it was a great recruitment tool for students. The college started highlighting this program in their magazine and in their alumni work, and in their admissions. We were on every cover of the admissions brochures. So it would have been pretty hypocritical for them to be advertising this and pushing it, and not allowing faculty to engage in this as their primary research, and their primary work. So they allowed it, basically. They were convinced that this was meaningful work that was scholarly and that was peer evaluated even without the peer review of very specialized professional journal. Without those peer reviewed reports, it was still peer reviewed in a variety of ways. They were receiving a lot of awards, EPA was recognizing us, and so on and so forth. So we just stuck with it, and we just did good work. And eventually they began to – I mean, I got tenure, basically, based on this work I was doing with ALLARM.

And there are a lot of other values, too. Of course, as a liberal arts institution we're very, very focused on education, and there were enormous educational values to the project, in terms of enriching students' undergraduate science education. It was a model for that, because students work for ALLARM – they are the staff. We do now have two professional staff, we didn't back then. But we've always had 10-15 students who actually do the work of ALLARM, including ultimately – once they learn how – doing training, and educating the public, and managing data and doing analysis and doing laboratory work and so on. And I guess another sort of indication of peer review is fund raising, and we were able to raise a fair amount of money from a variety of different foundations. And I think that was recognized by the college as a peer review of a sort, that all these fairly prestigious foundations were giving us money for our work, it must have some value.

I think there were a variety of different things that coalesced. When you think about it, to have such a narrow view of research – I mean, maybe I have a fairly cynical view of peer reviewed journals, but my sense is, once you establish a certain reputation then no matter what you write it gets into the journal. I've seen that time and time again. And you have to stay within fairly narrow boundaries of conventional wisdom – or be very, very clever, one or the other – in order to get into peer review journals. In some way it's a good process, but in other ways it's kind of a stifling process, research. And I think to be able to recognize that there are a variety of different venues for peer review, so to speak,

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http://www.dickinson.edu/info/20173/alliance_for_aquatic_resource_monitoring_allarm/1535/publications other than professional journals that are very narrow and only accept certain kinds of research – I admired the college for being able to make that leap. And they've done it for other faculty as well, I mean I'm not the only one. I think the most common example is that there are some faculty who do research *on* education. Even though they're in the physics department, they end up… we had this one physics professor who invented Workshop Physics[5] which turned out to sweep the nation in introductory physics courses. Now, she wasn't researching a physics problem, and publishing in a peer reviewed physics journal. She was researching physics education and publishing in education journals, and for a long time the college wouldn't accept that, and probably research universities wouldn't accept that. But the college did in this case, and in several other cases – also for extraordinary or innovative educational research – people have gotten tenure based on that kind of research which is a little bit different than a traditional scientific research. Again, I think that it depends on the college or the university, but I think that Dickinson has been pretty open minded, and more so in recent years. More and more are they open minded to different kinds of scholarly activities.

My dean was not as open minded. He told me it was service work, not research. We're evaluated on the basis of teaching, service, and research – but they don't call it research, they call it scholarly activity, and that's different, and I think that's good that they do that because that is a little broader. He said this would fall into the service category, not the scholarly activity. And I was so engaged in it, and so committed to it at that point in time, I just basically made the decision that I was going to do it, and if Dickinson didn't come around to recognize it for what it was then I probably didn't belong at Dickinson. I was young and stupid and I just took that perspective and I dug my heels in. And I just did it. And they did come around.

My background wasn't only coming out of diatom research. I don't know how to put this, but I have always been involved in social activism. I actually left graduate school – I was at Harvard in a PhD program in geology and paleontology, in the late 60's early 70's, and I was studying the ontogeny of trilobites under Steven Jay Gould, who was wonderful. But it just, you know – there was the Vietnam War, there was the environmental movement that was just in it's beginning years, civil rights – and I was just feeling, back then, even back then, that this was too esoteric for me, for my tastes. That I wanted to change the world. And I didn't think studying trilobites was going to change the world. And, in a very, very difficult period of time I basically made the decision to leave graduate school – and I was doing extremely well, I had a wonderful, world famous advisor, you know, I was set, I had a full scholarship and a stipend, I was totally set. I just, I just couldn't, I couldn't do it, with you know all this stuff going on around me. That was 1969, it was the big strike at Harvard, and all this activism going on around me, I just, I was swept up in that, I was of that generation. I just couldn't continue doing what I felt

[5] http://physics.dickinson.edu/~wp_web/wp_homepage.html

was very interesting and very intellectually stimulating work, but also pretty irrelevant in the grand scheme of things, depending on what your goals are. My goals were to change the world, or to make this a better place, so I left. And – I left. I went down to eastern Kentucky with my then almost husband and worked on welfare rights, and community organizing, and coal mining issues, and also strip mining issues and so on, social justice, environmental types of issues. I actually took a year leave of absence from Harvard, because I thought I might come back. But we ended up staying in eastern Kentucky for five years.

And then we came back, and eventually moved here to Harrisburg, and started teaching at Dickinson. But I didn't have a PhD, so I was not tenure track, it was just a Master's type of thing. They decided they really wanted me to get a PhD, because they thought I was a good teacher and that I had potential. So they pretty much sent me to Hopkins and gave me leave of absence, supported me in part, and that's where I got my PhD, and that's where I did diatoms. My orientation has always been one of wanting to – you know, I studied diatoms because I knew I needed to study diatoms in order to get my PhD, basically. I did it in environmental work, so it was more along the lines of what I was interested in. But frankly, after I finished counting diatoms for my PhD dissertation, I didn't really care if I ever counted them again. It's funny because from time to time I come around to being interested in them again, and I teach them, which is a lot of fun. We collect them, and we look at them, and we look at the differences between the species in acidified streams vs. carbonate streams and so on. I have fun with them – and they're good water quality indicators so in a sense they have a use and they're purposeful – but I don't want to count diatoms. I don't want to just – I don't want to go to diatom conferences, and I don't want to sit and debate about which species it is based on, how many striations there are per ten microns, it's just not what I want to do. And so it wasn't real surprising to me that when I had this opportunity to take some of my talents in terms of education – and I think what I'm good at is translating science in a way that people can understand it and appreciate it without oversimplifying it, I love to do that, and I think I'm pretty good at it – so I think that when I saw an opportunity to do that it was just a natural for me to do it. And when Dickinson said, "oh, this is extracurricular," I just said, "well, I'm, this is me, you know, I can't, I'm not doing diatoms. So, either…." We had to wait and see where the chips fall.

As I've said, ALLARM started just as a – it started out by just telling people to pick a stream of your choice, nearby, and the only criteria was that it could not be impacted by acid mine drainage because we didn't want to look at that issue. That means it eliminated a lot of streams in western Pennsylvania, but, in any case, other than that, just a stream that you enjoy and that you love and so on. And we want you to go out and once a week, we want you to measure pH and alkalinity, and send us your results. And what we found was – we were interested number one in looking at seasonal patterns, and especially with that dense of a sampling design. I mean, nowadays we have continuous monitors and things like that that some people can afford, and we have a sprinkling of that about, but most of the time, at that point in time the Fish Commission was going out maybe two times a year to a few select streams and getting pH and alkalinity measurements, and that was about it. And here we started having sort of an army of volunteers that were going out every single week, collecting this same information.

So we started seeing some really interesting patterns. We saw patterns of course with rainfall. We started to see patterns very much dependant on watershed characteristics, including altitude, as well as bedrock, as well as size, as well as land use – forested, and so on. And we began to look at ways in which we could characterize a watershed and predict whether it would be vulnerable to major impact by acid deposition. And so that was one of the research projects that we were looking at, based on all this data that volunteers had provided, and we could see, you know, these watersheds over here are heavily impacted. Well, what are their characteristics? And therefore what's the probability of another watershed with similar characteristics being impacted? Things like altitude, land use… geology of course was really big one. And so we began to make relationships between watershed characteristics and impact by acidic deposition, because some streams are very resistant. We had so much data that we were able to characterize streams based on their vulnerability – were they endangered, vulnerable, resistant, or very resistant to acidic deposition – that sort of thing. Prior to this time, that was done based on average alkalinity over the period of a year. We could do that, but then what we discovered is that even streams that were in the vulnerable and resistant category – not the endangered ones, which were acidified almost all the time – but the categories with some built in resistance, they would still go through serious acidic episodes, and we were able to document that. So if, number one, average annual alkalinity tells you nothing, or tells you very little in terms of vulnerability of streams and that you need a much more dense sampling design, then in fact the problem of the impacts of acid deposition in Pennsylvania had been underestimated. Significantly underestimated.

So those were the kinds of research questions that we were looking at, and the kinds of results we were getting. And in fact when we had tens of thousands of data points, and we presented this to scientists at conferences, they were so interested in the results that they would forget to ask us about things like data quality, or to say things like, "wait a second, this is volunteer data." It was just, "oh, but there's so much of it," and, "it's showing all these consistent patterns." We really didn't get… we weren't challenged on that as much as I thought we would be. So, the research questions evolved. We initially just started out wanting to document which streams were impacted, and be able to be watchdogs. But as we watched the patterns, then the research questions started to come up, like, "well, these streams are exactly the same size, why is this stream showing this pattern whereas that stream is showing a different pattern?" And, maybe, "could we predict what the alkalinity patterns would be like based on watershed characteristics?"

More and more these questions started popping up. And, in looking at the problem, to document that streams were having acidic episodes that we previously didn't even count, was important, I think. Maybe the most important. I would say our most important result was that the impact of acid deposition in Pennsylvania had been underestimated.

What happened from that, first of all, is that it became sort of a monster. I always said, "oh my god, I created a monster." It became pretty unmanageable because of the size of the state – and we were state wide – and the size of the response that we got from people. It became really difficult to continue working with so many individuals, and maintaining quality control and so on, across hundreds of miles of state. It was a lot of travel. It just became too big, I guess. And in addition to that, people began – we held these workshops all over the state where we were training them on pH and alkalinity, and people started saying, "well, you know something, what I'm really concerned about is the hog farm up the stream. And I don't really care that much about acid rain, I mean, this is really neat, but I feel like our problem is storm water runoff from all these new developments that are being built." And so, people just started talking to each other and then turning to us, saying, "well you know, how can we answer different questions? I mean obviously pH and alkalinity isn't going to tell us a whole lot about the hog farm, or tell us a lot about the farmer, or a lot about whatever. So what can we do, what else can we measure?" They really started pushing us to train them in other things. We began to recognize that – well actually our volunteers began to make us aware of the fact that – they wanted to do more than look at the single issue of acid deposition. Although they thought that was interesting, for many of them the streams that they were monitoring weren't affected, and there were other issues that they felt were higher priority in their particular watersheds, and they wanted to know, "how do I check out the CAFO [concentrated animal feeding operation] that's upstream?" or, "how do I check out the Super Fund site?" and, "is pH and alkalinity going to tell me anything about the sewage treatment plant impact?" And we kept saying, "no, you have to measure other parameters for that," and they were like, "well, why can't we measure other parameters?" And we said, "well, you know we can't, we're just not there yet, you know we can't supply that kind of support at this point in time."

And so we began to think about doing that. At first we didn't want to because we felt we had our plate full, but we began to realize that we needed to move in that direction. And then – also at the same time that people were pushing us to train them in other things – people were also starting to join together and form watershed associations. Some watershed associations have been in existence since the 1940's, but it really wasn't until the '90s that it started becoming a movement, where groups started thinking more on a watershed basis, and people started coming together and forming watershed associations, for stream clean ups and for whatever their concerns were. We began to realize that it might make some sense for us to work with groups, rather than with individuals, because it was much more efficient. The problem with working with individuals is that then we were responsible for the recruitment and the retention of the volunteers, and the complete communication and complete data management and so on. If we worked with groups we would be relieved of all of those tasks, and instead, we could focus on technical support. And we wouldn't have to keep these huge databases, we could focus more on providing quality control, quality assurance, and training on the technical aspects. And it would become possible to expand what we were doing from pH and alkalinity to whatever it was that was an appropriate thing to do based on their questions. We also reasoned that if we could be working with watershed associations, it builds community capacity, because we would give them, you know, a *raison d'etre* as it were. We'd give them a purpose and a project to do, so that they could stay together and build their own organization. And we could provide some support at some point, but we wouldn't have to be spending a lot of our time doing that, and so we started. At first we worked with a very local watershed group, and then we started spreading out a little further, and so on, and we began to realize that we could reach more people and address more issues by using the model of working with groups on *their* agendas than we could by working with individuals on the single issue of acid rain, which was *our* agenda.

We were starting to make these changes in the early 1990s, and this was still before we had a professional director. I was trying to do all this as well as teach. We were trying to change our focus, so we were working with some pilot groups, and it was pretty chaotic, as I was trying to do this. And then what happened is we sort of had this windfall. We got 100,000 dollars from some litigation on a company that had polluted a creek, basically – it's called clean water litigation money. What they do is, very often the judge will say, "ok, we're going to fine the company 100,000 dollars, and we're going to put that money into trying to correct the problem, or correct a similar problem, or do some good for the environment, rather than putting it into the general fund." I guess the judge asked somebody in DEP who happened to be pretty enamored by what ALLARM was doing, "do you know of any group that we could give this money to that's working to improve streams, and improve the environment, because this company polluted a stream?" And they said, "yeah, give it to ALLARM." So we got this 100,000 dollars, which was literally out of nowhere, and we decided that we were going to use that money to hire a director. The College was willing to at least give us some indications that if we used that money for a couple of years they might be able to also provide more support.

But even prior to receiving the funding, our philosophy began to shift. We were envisioning that prior to getting this money. And it was just a question of, how are we going to do that, how are we going to make that kind of transition, because we were at the point anyway where we needed some professional leadership, well, we felt we needed professional leadership, somebody who was full time, to devote to this. And so when we got the money it was really sort of, "wow. Ok, now we can move forward." It was almost like the visioning had already taken place and the idea had already taken place and when we got the money to hire a director, we did hire a director and she came in with the task of moving us towards a different direction. So when we got the Director on board, at that point I said, "we want to make this transition, and that's going to be your job, is to make this transition from acid rain monitoring to the Alliance for Aquatic Resource Monitoring." To broaden the focus and to work with groups, rather than individuals, and to mentor them through the different stages of the scientific process to get them to where *they* want to go. Continuing with the acid rain project, at least for a while was the hope, but then moving into working with watershed groups in this sort of bottom-up model that we had determined was the most feasible model for us to work with these groups, and that was the model that we felt philosophically in line with and that's what we wanted to do. And she was great, she was really on board. The acid rain project took a back seat at that point, and then she had the time to really launch this new program. The seeds of it were there, but she really launched it.

Now, when we did the acid rain project, it was a little bit different because there we had defined the agenda, we were working with individuals, we had a scientific goal that we were trying to do, we didn't have any problems telling people, "this is what you need to do, this is how often you need to monitor, if you're not interested in this issue then don't join us, this is what we're doing." But when we started working with groups, it became a different ballgame, and it was more like, "what are your goals, what are your objectives, what do you see as the concern in the watershed, you know why are you together as a group, what are you trying to work for?" And helping sort of facilitate a definition of their goals, and then ultimately helping them understand how monitoring could provide some answers to some of the questions they were asking, or provide some baseline data for future work, and so on. And so that was where our training kicked in, once we understood what their goals were, and then developing study designs that were manageable. But we felt very strongly that, if we want to hang onto them, and if we want them to be effective, we have to be sure that their concerns are the concerns that are being addressed. And in the process of addressing those concerns, they just might learn some stuff about science and they just might produce some interesting data for the scientific community.

At that point in time we were beginning to expand out and do this kind of work closely with just a couple of select watershed associations, including the Conodoguinet Creek Watershed Association[6] in our local watershed. I have memories of doing a lot of the pioneering work with them, in terms of determining study designs – before we really had our materials together, before we really knew what we were doing – working on developing study designs with them, working on data management with them. In some ways they were kind of our guinea pig for doing this, but I have to say that the philosophy of the model, as silly as it sounds, really came out of my experience and my commitment to the experience that I had in the early '70's, working with community

[6] http://www.cumberlandcd.com/~amcclain/ccwa/

groups on things unrelated to water quality. When I was in eastern Kentucky, I was working on community organization issues with some of the Appalachian communities there. When I first went down I was part of a VISTA program, Volunteers in Service to America[7]. It was in the old days with the Office of Economic Opportunity, and they drilled it into our heads that you don't know what's best for the community, the community knows what's best for itself, and you need to let the community define the agenda, you need to help facilitate that and build community capacity. That was the beginning of that kind of philosophy. We heard it over and over again, and that's what we practiced. And I was really committed to that.

And so when we started talking about working with watershed groups, and especially the Conodoguinet Creek Watershed Association that we really worked most closely with, and that we knew the members very well, it was very clear to me that they did know what they wanted, and that they did need to define the agenda, and that that would not only produce important scientific data – because their issues were important scientifically as well as socially – but that it would also build community capacity which is something I was really interested in. So I guess I already had this philosophy – I was maybe brainwashed in the '70's – but I had this philosophy that this was the way I wanted to work, that this was the best way to work with community groups, the most effective way, and the most sensitive way. And therefore I wanted to be sure that that's how we worked with community groups.

I will say that a lot of this may have also worked because of being at the right place at the right time. Again, what was happening even in the early days of ALLARM when we made this switch, was that people were starting to come together in watershed groups, independent of anything we did. This was happening across the state, and it was happening in other states as well. Here in Pennsylvania it was eventually facilitated by moneys. The state had this Growing Greener project where they put 600 million dollars into environmental concerns in the state. Their philosophy was they wanted to give as much money as possible to local groups to work on these issues. As a result, we had hundreds of watershed groups around the state that formed to attempt to access some of this money and get some of their concerns addressed. Most of them unfortunately ended up writing proposals, getting money, and then funding consultants to do the work rather than doing the work themselves, and then after the money disappeared, many of those groups disappeared as well. But before that, before the Growing Greener money, and maybe the reason we had the Growing Greener money was because this was a social movement that was going on across the nation where groups were starting to understand the importance of the watershed as the organizing unit, and the importance of taking direct action to try to address some of their concerns in terms of water quality.

[7] http://www.vistacampus.org/

Shermans Creek is a good example of that in many, many ways. Essentially what happened in Shermans Creek is that there was a proposal to put in a gas-fired power plant right along the creek, and quite independent of anything we did, the community was concerned. Some people in the community were very concerned about this, and they started getting together and trying to figure out what the impact of this power plant would be and how they could stop it[8]. It's a very rural community, but some hydrogeologists who worked for the state happened to live there, and actually had the expertise where they could put together some pretty valid critiques of the consulting work that was being done for the power company, which of course showed that everything was fine, it wouldn't have an impact on the creek, it wouldn't withdraw too much water, and so on and so forth. So they had a little bit of good science that they were working with, but mostly the community itself was just very, very anti- this power plant. They lived in a very rural and very pristine area and they didn't want a noisy power plant. It wasn't a big power plant, but nonetheless they didn't want it.

So they worked politically, really, and did a lot of organizing and did protesting, and so on and so forth. These are people that are very conservative, rural, farm families who don't usually do this kind of thing, but they felt pretty adamant about this. And they ended up winning – basically, the power plant said, "ok, we're going to go someplace where we might be a little more welcome." They left. It was just a political thing, it wasn't that they actually proved that the power plant would have this damage, and therefore the power plant wasn't given permits, it was more that the power plant just pulled out. And the group felt incredibly empowered by having done this – they actually defeated the power plant, they won what they were trying to do. And they'd been meeting on a weekly basis, and they had bonded to each other. So when it was all said and done, and they had this celebration party, they looked at each other and said, "well, what are we going to do now?" They really wanted to do something as a group, and they got the idea that, "well, you know there's going to be other issues in our watershed now because development is taking place, it's moving out from the Harrisburg area, there's going to be other industrialization-type issues, and maybe what we should do is form a watchdog group for the watershed and be sure that we're in touch with these issues and get some sense of the state of the creek, so that when these kinds of things occur again, we'll have some information and some data and some ammunition as it were to do what we need to do."

At that point, I actually lived in the watershed, so I was really aware of what was going on, and people said, "well, maybe we don't really know what to do, could ALLARM help us?" So they came to us, basically, and they said, "what can we do? We'd like to document the state of the watershed, and we'd like to get our ducks in line for what we see as coming down the road." And so we said, "well, yeah! This is perfect, you guys should do some monitoring." And that's how it started. And so they asked, "well, what are the

[8] http://www.shermanscreek.org/about-us.html

steps?" And we explained, "well, the first thing you need to do is you need to figure out what your goals are, you need to put together a study design, you need to figure out what your resources are…." We basically started with a study design where we went out there, and once a week for a few months we facilitated a discussion with them on what might be the questions that they're asking, what might be their goals, and how they might accomplish that in terms of monitoring. As it turned out, really what they wanted to do is collect baseline data. They wanted to see if there were any areas that were in trouble that they should target for some sort of restoration, they wanted to see what areas were very, very high quality and needed to be protected. And they just wanted to get data that they could then present if a problem came up in terms of, "well, this is what the data was prior to the project and we have this kind of data and we expect you not to degrade the creek beyond what it is now." So that was their philosophy, and those were their goals. It was really to collect baseline data.

And so they started organizing. They had really a very small group of leaders, two or three women who were willing to take on the lion's share of the work. In some ways that's a little different from some of the watershed groups we've worked with before, where there's been a bit more broader participation, but this was a very top-heavy kind of deal where these women just – they spent a lot of time and a lot of effort organizing things and making sure that they had volunteers, are recruiting volunteers, and knocking on doors and so on. And they were able to build the viable organization, and once we got the study design, we said, "ok, given that these are our volunteers and these are the sites that we have, we're going to be doing monitoring for a year, and then we're going to check back in and see what's going on." And so we started with a training, and we started with quality control, quality assurance, where we did sample analysis with them, and then we taught them how to archive their data and how to manage their data using Excel. So they were managing their own data, we were not doing that for them, although we were checking in with them from time to time. And they just started moving forward.

Everybody kept checking in, and they had lots of questions, but they were satisfied knowing that they were collecting baseline data for a while. And we kept telling them that we're not really going to be able to do any kind of interpretation until we have at least a year's worth of data, because things vary so much seasonally and we need to see what those patterns are. And so after either a year or two, I can't remember, we held our first data interpretation workshop with them. Actually, we held two of them – the first one was where we had them look at some virtual data that we had made up in a watershed that was pretty similar that had the same kinds of – some densely developed areas, and some ag areas, and so on – and had a series of data on the same water quality parameters that they were measuring, and so they began to see how those kinds of parameters would vary seasonally, and how you could tell if something was going wrong, and something was too high or too low. That's what that first workshop taught them, as a self-discovery sort of thing. And then the second workshop, what we had done is we had taken their data and put it in the same format with the graphs, and we used box-and-whisker plots for distribution, and gave that to them and said, "ok, now here's your data, it's in the same format as the virtual watershed that we did last month, so now you need to look at your data and you need to find the story in that data." And they did! They found some critical areas, some interesting spots, some things where they had generated hypotheses about why things look the way they do, and then they went back and they said, "ok, so now that we know this, what we'd really like to do is we'd like to have more volunteers – we want to look at the area around site 5 because something's going on there – we need more people to look at the impoundment above the dam." They decided they really wanted to do bacterial sampling because they observed in their studies that a lot of kids are swimming in the creek, and there are certain swimming holes – they decided, "well, we want to do a swimming hole study." So in other words, after a year or two of experience, they began to redesign their study and that was great, because it kept it vibrant, it kept it alive, and they were generating new questions from some of the data that they had already collected, and so we went back and redid the study design, again facilitating – this time they were a lot better at it, and off they went for another few years for doing that. And so this was sort of a process that we continued with for a while.

Now at some point down the line, after they'd collected I think about 5 years worth of data, we agreed to put together a technical report based on the story that they found in the data, plus any insights that we could find as well in the data. And so we did put together this technical report, and it was very complete, it was completely based on their data, and they were very pleased with it – we came up with a series of recommendations based on the story that they had found, again working with them on recommendations. And so we really did play a role in sort of moving their own observations and their own story into a report that could then be distributed – and that was scientifically appropriate, you know, the language used was appropriate – and we sort of helped them a lot with that, and so we wrote that. And then they took that report and they actually went to every single municipality in the watershed – and Pennsylvania is full of municipalities so there were a lot of them – and gave them copies and talked to them about it, and asked them to use it when they start thinking about zoning – and there's not much zoning out there just yet, it's just starting – when they start thinking about zoning, when they start thinking about land use, think about the creek and so on. So that was one of their action things that they did with it.

And there were other projects that were spawned off of this. One was, we work with them in an educational project. They work with the high school, and they got together with the high school teachers and decided that they would focus on the creek in a variety of different courses, like in a history course, and a biology course, and they would build up the story of the creek and the story of the watershed with high school students. And then they'd have a town meeting, and the high school students made their presentations at the town meeting, and of course all the parents came. We had a lot of students working on that project, in fact I recall that Julie, who is now the director but who used to be a Dickinson student, was one of the students who worked on that educational project a lot with the kids up in the high school in the Shermans Creek watershed. And Shermans Creek Conservation Association was really active in getting support from teachers to do this kind of work and it actually turned out to be a really interesting project because the kids were looking at the creek in a number of different courses that they were taking which is kind of an unusual thing for them to be doing in high school.

And then there were some other projects that were spawned that weren't actually directly monitoring, but that were educational awareness, research into other aspects of the watershed like it's history and demographics, and there was a study on the mills that were on the creek, and that sort of thing. What finally ended up with Shermans Creek is that they got funded to write a rivers conservation plan[9], they worked with the state to write a rivers conservation plan. And if you look at that rivers conservation plan, it looks very familiar, because much of what we had put in that technical report – which was their work – showed up in the conservation plan, much of the data. I mean, really nobody else had the kind of data that they had. And much of the data that they found showed up in the plan and was used to try to make recommendations for land use and so on in the watershed, and so the rivers conservation plan – for whatever that's worth, and I'm not sure how much it's worth, but for whatever it's worth – kind of grew out of the watershed's work and grew out of that technical report that we ended up producing with them.

It became pretty clear to us that the result of working with people on their own problems, that they designed, was much more engagement on their part and much more willingness to carry a large burden of the work, and really put in the time. Whereas with our acid rain people … they weren't as engaged, and they didn't very often do anything with the data. We would collect their data and then we would send them reports but they very rarely did anything with them. Once in a while they would call a legislator or something, but they really didn't do much. Whereas with groups, they would organize, and they would know ahead of time, "this is how we're going to use the data." They'd collect the data, and then we could mentor them through every stage of that. And we found that it really led to building community capacity, empowerment, better science education – it just felt like we were doing a better job at some of the goals that we had, than when we were doing the acid rain project. But I will say that I'm not sure about the research outcomes – other than that we have a lot of baseline data, which is very interesting. The research outcomes for the acid rain project, because it was a more top

[9] Central Pennsylvania Conservancy and the Shermans Creek Conservation Association. 2008. Southern Perry County Watershed Conservation Plan. Available online at: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CC4QFjAB&url=http%3A%2F%2Fwww.shermanscreek.org%2FChapter%25201%2520MASTER.pdf&ei=VeR4U--AFonKsQTyxILoAQ&usg=AFQjCNE4oZ2BcOYHf0Ov2I8KMAS6VRpIlA

down project, were probably somewhat of more interest. I mean, I don't know that I should really say that, but the research outcomes at least weren't any more interesting than the acid rain project, maybe less interesting.

And so we did get the money and we hired a director and her job of course was to raise additional money for her salary in the future – because it was soft money – as well as run the program. And after she came on board the program significantly changed, not only in terms of our focus and the model that we were using, in terms of public participation and scientific research, but also in terms of the supervision of students, the efficiency, the actual work of the students, or – they're staff, I mean, but they're students, they're student-staff. The work of the staff changed, it became much more organized and much more productive and it really sort of switched the organization in terms of our ability to deliver services. Having that full time professional director was very critical at that point in our history.

One thing we did was, we *were* called the Alliance for Acid Rain Monitoring – and we challenged the students to keep the acronym. It's kind of a controversial acronym. The Department of Environmental Protection has told us many times they don't like our name, as have other people. And it seems like, as we move into whatever era we're moving into in the last couple of decades, the name has become less and less popular. But we like our name, and we wanted to stick with it, we felt like that's what people knew us as. We wanted to keep the acronym, but we wanted to broaden it out. So the students immediately came up with this idea of calling us the Alliance for Aquatic Resource Monitoring, which kept the acronym and took away the acid rain. And so we did, and we changed our logo, and we really changed our work significantly.

And now the goals of the projects have changed. I would say that the model we've been using, when we became Aquatic Resources as opposed to Acid Rain… you know, the acid rain project had an agenda that was set by the professionals, so to speak. I mean, there's a problem – acid rain – we want to study it, we want to document it, we want to contribute to a database and so on. And we want to be able to document patterns. So initially it was defined entirely as an educational project. But then it became very clear to us that this was a good research project too. And so then it became defined, very fundamentally, as, we were doing research using volunteer-collected data. And we kept all the data, and we did all the analysis, and we – you know, we'd share it with our volunteers, every year we'd send them an annual analysis of what they had done. We had, by the way, some people doing this for like fifteen years, every single week. That's unusual, but we had about a handful of people who did from ten to fifteen years. Anyway, so the goal was very clearly, and, in their minds, what they felt was, "we are contributing to a database that is established at Dickinson College, and those guys are analyzing it and there's going to be interesting research that comes out of it." And they were ok with that.

And then ultimately, and not all that long ago, just a couple years ago, we closed down the acid rain project. We still have people who insist on sending us data [laughing]. We thank them kindly but we're not really doing anything with it. I know, it's important to them. And in retrospect the nice thing about the acid rain project was that it was weekly, whereas with our broader issues with our watershed groups, we usually recommend monthly monitoring, because they do more and it takes longer. But the pH and alkalinity is a quick thing, and I think one of the main outcomes of the acid rain monitoring, from informal feedback that people gave us, was that visiting the stream once a week during the period of a full year – which was what was required –and seeing all the seasonal changes, and watching the moods of the creek, and getting a real sense of place, was the most important thing that came out of it for them. They really looked forward to that, and a lot of them did it with their grandkids, or their children, and they just really enjoyed that once a week, "oh, it's Sunday, let's go, we've got to go get a water sample." And then, "oh, look, there's a new duck," or, "now there's the babies," or, "the ice has broken, or the…" whatever, they really…. They would always write little comments on their data sheets about what was going on in the creek, which was great. One of the unmeasured and unspoken outcomes was probably the most important outcome. For society, I mean – for people to build a sense of stewardship and to care about a place, is to me what we need in this world, and that's what's going to ultimately change people's world views about environmental issues. I mean, these people, you *know* they care about this creek. And that's the first step – they care about it and to some extent they understand it and they have a kind of intimate relationship with it, and that's the foundation of stewardship. So it wasn't just that they learned about pH and alkalinity, which was fine and important, or they learned about acidic episodes, or they learned about you know the relationship between rainfall and pH or whatever, but that they really learned to love a place. And to hopefully, at some point, feel motivated to protect it, and others like it.

I don't know whether we really do anything to foster that. I think it comes from the activity, more than anything. There's a couple things. First of all, I think it comes from the activity. It's kind of like…. My husband and I take the dogs for a walk in the wee hours of the morning, at the local park. And, I just have this strong attachment to that place because I have seen it in every day of many years. I've seen it change, and it grow, and I've seen new things come up, and old things go, and so… I really think it's just the activity, it's something that we do, it's just visiting it and observing it, I think that's important. I think to some extent people who chose to get involved in this project were people who already had some other appreciation for nature, and an appreciation for protection of our resources, or else they probably wouldn't have been in it. So in a sense you already have an audience that has an inclination towards that sort of thing. They had a concern – many of them actually were anglers, and they had a concern about the change in the fisheries over time that they had noticed, that they no longer could catch brook trout and that sort of stuff. We certainly try to encourage this when we get together in our trainings. Lots of times people would talk about this, and we would try to encourage that conversation. We did encourage people to write comments to us or send us pictures, and we would sometimes respond to that when we had time.

But I do think it's more just the feeling they had a sense of purpose. They were contributing to a database that was going to document the impact of acid rain in Pennsylvania, and in order to do that they had to go every week, rain or shine, in fact it was very important that they go when it rained, and snowed, and so they did that because they felt like they had made a commitment to it. I think the only thing about the project that really fostered these feelings was the requirement to go out every week. I mean, whenever we'd do reports then we would send them information, we had newsletters, and we talked a lot about environmental protection and stewardship and how important it was and the problems of acid rain and so on, we did try to educate them about the issues. But you could be educated about the issues and still not have that deep seated connection. And that deep seated connection came out of the act of visiting that place, and struggling to get in there in the snow and so on. But I think they started to really appreciate it, and their information about that place became really deep for them.

Now with the new project, the goal was much more problem solving at the local levels, of a problem that they're concerned about. It was problem solving, it wasn't research. I mean, you need to do a certain amount of research to problem solve, and we needed to collect the baseline data to understand, to document what the problems were, but our real goal was data use in problem solving. And that's a little bit of a different kind of research… it's not really scientific research that would be particularly interesting to anyone but people in the watershed, or scientists in the watershed. Now that's not to say that a scientist couldn't jump in and utilize the data across watersheds and find some interesting patterns and do some data crunching and some interesting analysis that would be publishable in scientific journals that would show some patterns or answer some questions, but that's not really the goal of the project. The goal of the project is, "we want to target areas in our watershed that have poor water quality so that we can fix the problem." Or, "we want to show that the hog farm is leaking crap so that we can fix the problem." Or, "we want to collect baseline data so that we can come up with water conservation plan so that we can protect the pristine areas in our watershed." They're all action-oriented kinds of goals, and the data collection is more towards problem solving, things like, "we want to change the way land is used, we want to change the zoning, we want to upgrade the stream." They're addressing policy issues as opposed to, "we want to do scientific research."

The whole thing about building community capacity, and allowing communities to set the agenda and working with a bottom-up model, requires that you be responsive. It's our philosophy, it's very intentional. One thing that you learn very quickly is that these groups change. They change in terms of people – people get burned out, and new people come in. We've had groups that have been very, very active, and then they just dwindled down to almost nothing at all. And we've had groups that have been almost to nothing that have all of a sudden had this big boom, and a bunch of people come on board, and they all have different goals than what the original people who ran the watershed had, and they have different ideas about things to do…. We can't be completely responsive, I mean, there are only a certain set of tools that we have, and so in a sense we can only be responsive within that set of tools that we have, there's only so much we can do. We're not able to train them to do everything, so we do try to stick with the monitoring and the water chemistry, macro-invertebrates, visual assessment, and this stuff.

I think that what I've seen is that as time goes on, as we're working with community groups there's less investment on our part in terms of support that they do learn to work more independently. I do think that we always have to do quality control, quality assurance. We always have to do that because that's the only thing that gives their data credibility. So we do need to do that. I have seen groups go back and revisit a study design and basically, pretty much do the basics without us, but they may need to ask something like "is it possible to measure iron using a field kit?" You know, stuff like that. And we do need to provide that kind of support, but they can actually figure out what it is they need to be doing. I mean, I think that we don't need to – that as we work with groups, and as groups become more experienced, they can do a lot more on their own and we don't need to do as much investment. The initial training is always the greatest, and after that they can – we've seen groups train each other, lots of groups do that especially on the chemical monitoring. We hold one or two training sessions, and after that, the groups themselves hold the training sessions and they train their new volunteers, and so things like that we can do. So I guess I don't really see them ever being completely independent, but I can certainly see that the older groups, the groups that we've worked with for longer periods of time are definitely require much less work from us.

And the other thing that we do I guess is that we do very intentionally have our staff – our students – participate in research, we call it our aquatic research students. And what they're doing is they're helping to retool us. So for example, when we started with the Marcellus shale stuff, we said, "oh, well, this is obviously something we'd better be responsive to, this is really going to – this is extremely important, and we need to be able to figure out what's going on, and what are the issues with Marcellus shale, what are the possible sources of contamination, what is the contamination, what are the effects of contamination, how likely, blah blah blah." We need to educate ourselves. And so we set students on to do some research on flowback water, "what are the major constituents of flowback water? And if we could only measure two constituents, what would they be? Take a look at what kind of things should you look at in terms of visual assessment, what's likely to go wrong that you could visually assess?" And so we try to get our students to kind of keep a little bit ahead of the game doing research that will allow us to tool up. So I think that's one thing that Julie [Vastine] and Jinnie [Monismith], our assistant director, have been really good at sort of putting students onto things that we anticipate are going to be needs that communities are going to turn to us for support, and we need to be able to provide that.

We have anywhere from 10 to 15 students per semester that are actually employed by ALLARM, and that do the work of ALLARM in many ways. They do laboratory analyses, they do workshops, they do environmental education. They're out there in the community doing things under the supervision of the ALLARM directors. And then some of them do research, background research. So there are lots and lots of different jobs that they do. Those are the employees. And then in addition to that, in almost every course that I teach that has a lab component we do projects that come out of questions that are raised by community people, and sometimes, depending on the course, we actually respond directly to community requests. For example, a program that I was involved in for four years, we got a grant from the Henry Luce Foundation, and we ran what we call a mosaic, which is an integrated semester, it was called the Watershed Based Integrated Field Semester, where students took the equivalent of their full-time course load with two faculty members, so we had them full-time, we could travel with them. We did a comparative analysis of environmental issues in the Chesapeake Bay drainage basin and coastal Louisiana. We traveled to Louisiana. So as one of their courses, they did an independent research, and what we did for their independent research was we gathered together all of the watershed associations in the local area that we've dealt with, and we invited them to come to a panel discussion and explain to the students, give the students ideas for research projects that they were interested in, that they wanted the students to do. And so every single one of these students, there were about twenty of them, actually did projects that then went back to the communities, the papers and the results and stuff went back to the communities. They had to do a presentation for the community group, they had to actually go to one of the community group's meetings, and so on and so forth. And these kids really connected with these, but it wasn't by being employed with ALLARM, it was by taking a course that took advantage of this.

And so one of the nice things about ALLARM is that it's presence at Dickinson allows for that kind of – some people call it service learning, community-based science – that kind of work to go on in the classroom, because we have this resource of this group that can connect us with these kinds of issues, with the community. So both groups of students, both employees which really tends to hit a smaller group of students, the more elite group so to speak, and then also students in the actual courses. Most recently I taught a course in fresh water ecology, and everybody did a project that was related to ALLARM's protocol for Marcellus Shale monitoring, and an attempt to try to expand and improve that protocol. And it was really helpful, there were some great things that the students came up with.

I actually wrote a chapter in a book on service learning in environmental studies education. This was in a book that was published in 1999, called, "Acting Locally: Concepts and Models for Service Learning in Environmental Studies[10]." Harold Ward was the editor, it was part of the American Association for Higher Education's series on service learning in the disciplines. And my chapter was "ALLARM: A case study on the power and the challenge of service in undergraduate science education." I think it just sort of summarizes a little bit some of the things that I feel in terms of the student role in ALLARM. I guess it is providing opportunities for students to feel that the work that they're doing is actually going to make a difference to people, or to an issue, or somehow it's going to be useful. And the great part about ALLARM is that the students actually get an opportunity to interact directly with the community. And what it does is it sort of increases, number one, their appreciation of their own education, because they suddenly realize, "wow, I actually know something that somebody else wants to know, and I can teach it to them." So it increases their appreciation of their own education, and it also motivates them in terms of their own education to do more.

We have students who work for ALLARM who maybe are environmental studies majors who are interested in social science and economics and politics and so on, and they suddenly realize, "you know, I really need to take a course in chemistry, because I don't really understand enough about the science behind this to present it to volunteers and to present it to community people, and so I'm going to go take a course in computer science, or go take a course in math, or something like that so I can begin to understand." And on the other side, the science students saying, "oh, gee, I'd really like to know something about principles of sociology, or the psychology of environmental behavior, because I'm dealing with these issues and I don't have any background with this stuff." So I think it allows them to move across disciplines, and also just gain some – a higher sense of motivation for the coursework that they're doing, which is generally unrelated to their ALLARM work, except that they see the connection, and they see the relationship.

The other thing that it does is it provides them with – I feel like a higher sense of accountability, in terms of the work that they're doing. And this is especially true not only the students that work for ALLARM, but very often I will do projects in my regular courses that are related to projects that ALLARM is doing, or that are related – come out of a community concern, or out of a community request. And when students are actually doing a project where the results are going to go back to the community, and are going to be used by the community, they feel a whole lot more accountable about what they're doing. And I get things that I'd never get in a regular course, like, "well we really need to go back and re-sample, because there's too much uncertainty in these results," whereas if it were a regular course, whatever the results would be, they would hand in, they

[10] Ward, H., & American Association for Higher Education. (1999). *Acting locally: Concepts and models for service-learning in environmental studies*. Washington, D.C: American Association for Higher Education.

wouldn't care. So those are the kinds of things that it does for students. I think it really changes the nature of their education, and the values, the importance of their education, when they're working on real issues. Especially for the ALLARM students, the students who are actually employed by ALLARM, when they actually have an opportunity to meet face-to-face with the people that are interested in these issues, and then are learning from them. We have some great student quotes things like this one student who said – she was at this workshop, and she – this one volunteer stood up and he said he'd been working with watershed issues, and in watershed management, he was just a volunteer for 25 years, and she was just stunned by the idea that she thought *she* was the expert, and here's this guy who's been working in it longer than she's been alive. It builds this incredible respect for local knowledge and the idea of people being active learners, after they're finished with college, and it sort of puts the college education a little bit in perspective for a lot of these students as well. So lots and lots of interesting benefits, I think that come out of working with community people, for students.

And we don't always know the answers at all. And so not only do we have students do research, but we do research too. I spent my whole sabbatical developing a protocol for Marcellus shale monitoring. I started with what the students had already done research on. And we had some students, not only student staff but we actually had students in some classes who had done some independent research on what would you measure if you were volunteer – what could you get volunteer monitors – what kind of contribution could they make, what could they measure that might detect some kind of contamination from Marcellus shale? So I started with the stuff that the students had already done, and then tried to move on from there and access the scientific literature, and actually more importantly, access other people who were working in this area, and seeing what the latest was in terms of scientific knowledge of flowback water and so on. So I focused my sabbatical work on that. I guess in some sense maybe what you could say is that one way we've been able to respond to volunteers is to anticipate what some of the big issues are going to be and tool ourselves up so that we have the tools to respond to that.

Going to conferences and seeing things and networking at the information-gathering level is really important to stay ahead. Because some of these issues are really cutting-edge issues and you can't necessarily go to the scientific literature and find what you're looking for. Yet. It's slow, as you know the scientific literature is slow. And by the time this stuff comes out – I mean, I have a colleague at Bucknell University who's a geochemist, who got ahold of all these flowback samples, and he's been doing all this geochemistry on this stuff, he's just beginning to publish stuff. He's been working on it for a couple of years. Well, I needed to know, ok, what could we monitor that might be a critical flag that would show that we've got a contamination event? And talking to him was really useful, because he's done all this work, which is as-of-yet unpublished. And he was willing to share it – to some degree. I mean to really help, to answer my questions it wasn't necessary – he didn't send me his data tables, but he did explain that these are the patterns that he's seeing, and this is how it's different from acid mine drainage, and so on. And it was just so helpful, and that helped us develop our protocol in a way that now the scientists like him that are working on this are looking at our protocol and saying, "yeah, that's good. It's good."

The number one thing is that you need to have a network of colleagues, of people who – it really helps us that people in Pennsylvania know about ALLARM, and know I've been working for a long time, and ALLARM is on a number of boards of environmental groups, like the Clean Water Campaign, and things like that – and so we have this network of people that are working on these issues. We're in touch with DEP, we're always calling them and asking them questions, and they know us, and they're ok with us, you know this sort of thing. And so that's the number one thing, I think. When I think about working on that Marcellus shale protocol, the thing that was most helpful for me was not the scientific literature, because not much has come out in the scientific literature. What was most helpful was going to conferences, meeting people, geochemists who were working on this, talking to them, telling them – asking for their help, asking them to look at protocols and critique them, and just working trying to get input from people who have a higher level of expertise. And so I think that that's something that ALLARM is, a little different model maybe than – well I'm sure that Cornell Lab of Ornithology, I'm sure that some of these folks who are running these citizen science programs are also in touch with other researchers and also with state agencies, and environmental activists. And scientists who work for advocacy groups for the environment like NRDC, or Sierra Club, or the Chesapeake Bay Foundation, that actually have a staff of scientists that you can call and say "what do you know about this?"

The more informed and knowledgeable the public is about a natural resource or conservation issue, the more likely that there's going to be policy implemented around that issue. That there's going to be *good* conservation policy implemented around that issue. And I think there are some studies, some statistics, that have actually shown that – and that's our observation too – if the decision-makers, whether they be the municipal officials, or the state officials, or even the companies, or whatever, if they are aware that there's a significant cohort of people who understand this issue and who are educated about this issue, and have actually participated in collecting data around this use, they're much more likely to move forward on implementing policy. And I don't know if it's true in New York, but it's certainly true in Pennsylvania, even at the state level, that the issues that get addressed are the issues that are by and large raised by the stakeholder groups. And the knowledge that there are stakeholder groups out there that are doing this kind of work is very motivating to decision-makers to make something happen around those issues. So I do think that it translates into maybe better policy, maybe just policy. But I think that it can actually translate into positive changes for conservation.

We have found that, for example, for the Marcellus Shale stuff – I hate to say this, but the truth of the matter is it doesn't really matter if our volunteers find any contamination or any violations. The more important thing that translates into some sort of action is the fact that they're out there, and the fact that the companies know that they're out there. And in certain areas the companies know that a lot of them are out there, and that they're monitoring certain streams, and they're going to be a little more careful about their practices if they feel that there are people in the field that are experienced and knowledgeable and know what is a violation and what's not a violation. And so I really feel like our public participation in scientific research, besides producing interesting data – which by the way, it seems like there's a lot of interest in Pennsylvania in our data right now among researchers, which is interesting. Which is maybe because it's so widespread, and because it's such a hot issue, that a lot of people are talking about trying to figure out ways to develop databases where they can use our data. So there's a lot of interest in the data on the part of the researchers. But as far as the actual management goes, it seems as though just the fact of having people out there, and having an educated citizenry, is going to change management practices of the people who control those management practices, which are the companies in the case of Marcellus Shale issue. And so I think we're seeing some of that happening, we're finding that some of the companies are very much aware of who's out there and where they are, and you can bet that it's going to make it very hard for our volunteers to find violations, because they know they're out there, which is great. Which is exactly what we want to do, it's preventative in that way. It's not going to prevent drilling from happening, and it's not going to prevent or slow down the issuing of permits, but at least it may result in better management practices of the actual drilling process, and the waste and water disposal, and so on.

Most of the data that is being generated is interesting at the local level, and is important in justifying protection or restoration or non-degradation, and so on. But whether or not it's scientifically important in the sense of revealing new patterns in stream ecology, I don't really think so. Again, I think that the larger, more top-down model[11]s are better at that, partly because they're defining the issue that's being studied as an important issue in science. They're specifically collecting the data to contribute to our scientific understanding of something like climate impact on bird migrations, or whatever. And in the model that we've been using, I think that's less likely to happen, that we would find something that we could generalize, and that would be really important to contribute to the scientific literature, and we haven't really done anything. Although some volunteer monitoring programs have been able to contribute to the scientific literature, again more

[11] Candie has published thoughts on different models of working with the public: Wilderman, C. C., Barron, A., & Imgrund, L. (2004, May). Top down or bottom up? ALLARMs experience with two operational models for community science. In *Proceedings of the 4th National Monitoring Conference, Chatanooga, Tennesee, USA. National Water Quality Monitoring Council. http://water. usgs. gov/wicp/acwi/monitoring/conference/2004/proceedings_contents/13_titlepages/posters/poster_235 . pdf*.

on a local level, but still things like – for example, if we really wanted to, I'm sure we could contribute to the journal of the Pennsylvania Academy of Natural Sciences, because that takes a lot of local stories. And that's kind of what we're doing, is we're telling a lot of local stories. Scientifically telling it, but telling a lot of local stories.

Now the acid deposition project, there's no question in my mind that that project did contribute to our scientific understanding of acid deposition in Pennsylvania. And we did do some – again, our focus isn't on publication, but we probably should have focused on publishing that data in a more formal way than we did. I mean we did abstracts and presentations at scientific conferences, and one of our long abstracts, like a two-page abstract, showed up in a document that was documenting acid deposition in Pennsylvania. Basically we were able to show – because we had such dense sampling every week, we had seven hundred sites across Pennsylvania that were monitored for at least a year on a weekly basis – we were able to pick up all kinds of acidic episodes that nobody even knew existed. And we were able to challenge the classification that the state and the Fish Commission had in terms of streams that were vulnerable to acid deposition, endangered by acid deposition, or resistant to acid deposition because they were doing it on the basis of a couple of alkalinity measurements over the course of a year. They were greatly underestimating the vulnerability of streams in Pennsylvania to acidic episodes, and we were able to document that. So that's important I think, but again that was more of a top-down kind of a project and it was across the entire state, so it had a much wider geographic range, and so we were able to come up with more generalizable kinds of findings and I don't feel like the watershed projects are really designed as much to make a contribution in that area.

And I think it's going to happen with the Marcellus shale too. Once we get all the data together, and once we're at it for a couple of years, I think we're going to find some interesting, possibly some very interesting patterns of flow and total dissolved solids, or conductivity relationships. I think that that's potentially a scientific area that we're going to be able to make a contribution to. As well as a frequency of contamination sources, groundwater flowing to streams – I think there's a lot we might be able to do with that once we get enough data on board and once we figure out how we're going to manage the data, which is a whole other story. But for the watershed groups, in terms of the actual scientific data that's produced, I think it's important on the local scale, and I think that the baseline data, just like any baseline data, tends to sit around in a report until there's a development in place or there's a proposal for a development in place, and then they pull up the baseline data, and you may or may not have some arguments about what needs to be done to mitigate the impacts of that development based on baseline data that you have. I mean, we've used it a little bit in that way as well – there was a thousand-house development that was proposed for the Conodoguinet Creek watershed, and those folks used the data[12] that they had collected to make it really clear that the developers needed to use best management practices and that if they didn't, we'd be able to tell. And they did implement it – it turned out to be a really model green development in terms of low-impact development, they really went at it because there was a watchdog community. So is that scientific? I mean, it's using scientific data, but it's not actually contributing to scientific knowledge so much.

Crossing the disciplines between being a scientist and doing community work – working with communities is valued in academia for anthropologists and other social scientists, but for biologists it's not valued. You know, we'd rather you be working in the laboratory, or out in the field doing ecological research, or whatever, but to be working with community groups is not considered something that's appropriate for a scientist to do, in academia. I think the main reason for that is because if they're PhD based, and if they're academics-based, I mean if their home is in an academic institution of any sort, that kind of work isn't going to be valued for their promotion and tenure process. And, I mean I've had a lot of PhD people say that to me. "Oh, god, I wish my university would support that kind of work, but they won't, you know there's no way." And of course I ran across that too, in the beginning, but I think that people really are dissuaded if they want to climb into a secure position in academia, they're not going to be doing this kind of work, they're going to find something else.

What's happening, happily, in the environmental sciences, is that these sorts of disciplines are being bridged. More and more people are coming into academia that have had very, very interdisciplinary training, in programs where they've actually gotten a degree in environmental science rather than a degree in biology, for example, and they move pretty seamlessly between these disciplines and for them it's a perfectly natural thing to primarily be a scientist but to work with community groups. And as those people are beginning to populate academia, at least in the environmental studies area, academia is opening up a little bit more to reviewing the role of scientists a little bit differently, that scientists actually also have a role to play in terms of solving the problems of the world and working with communities and so on. So I do see that there may be some shifts of that in the future, but for the disciplinary biologist who gets a position in academia in a biology department, doing this kind of work, unless it's an unusual department – you know their colleagues, his colleagues or her colleagues are going to look at her and say "we don't understand what you're doing, and we don't really value what you're doing." At least that's my experience in talking to folks over the years. I do think that's changing.

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[12] See, for example, Pennsylvania Environmental Council. 2004. Middle Conodoguinet Creek Watershed Rivers Conservation Plan. Available online: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=6&ved=0CEcQFjAF&url=http%3A%2F%2Fwww.dcnr.state.pa.us%2Fcs%2Fgroups%2Fpublic%2Fdocuments%2Fdocument%2FD_001466.pdf&ei=3OZ4U-a-F86zsASxioC4Cg&usg=AFQjCNFjXVxD6d6Ac5PAnzvn39rWPaCXwQ

One thing I've thought about before is, about shifting the focus and trying to do more with getting the scientific data published and looking at it from what kinds of contributions it can make to science. And I think – I don't have any real answer to that except it would take resources away from the work that we're doing. We're so stretched for resources, I think that, wow, wouldn't it be great if some faculty member would say, "I'm going to take this on," you know, "I'm a scientist, I think that we've got an enormous amount of data here that could be interesting to science, and I'm going to find ways in which different themes that we can publish this data under…" and so on and so forth, and that would be great. But we don't have the resources to do that and so we've just made some choices, at least initially. For example the acid rain data, when I was working by myself, at first I thought – and I think I told you this – "well, this is going to be a great educational project, but we're not going to get any data that's worth anything." And I had no goals whatsoever to do anything in the scientific literature. And then when the data came in, and we began to see the story evolving of this underestimating the impact of acid rain in Pennsylvania, it just was like, wow, I mean, this is really interesting scientifically. And I did work with some students and we worked up the stats and we made graphs and we showed the percentage of different streams which have different kinds of patterns, and the acidic episodes, and all this kind of stuff. But we never took the time to put that into the scientific literature. It takes a lot of time as you know to get an article published. And it just wasn't the choice of resource expenditure.

We prioritized working with the community, taking the data and utilizing it – for example, we spent a lot of time using that data to try to convince the Pennsylvania state legislature to pass an acid deposition control bill. We testified using the data, we sent reports of the data, and we did spend some time showing the data to the scientific community. And then when the Clean Air Act amendments were in the process of being passed in 1990, for the first time they began to talk about acid deposition control, I think it's Title IV now. And they actually incorporated that into the Clean Air Act amendments which was the first time they actually mentioned acid rain. We feel like we played somewhat of a role in showing them how serious this problem is in Pennsylvania based on this volunteer monitoring data. And in some ways it was – I remember when we were testifying in front of the Pennsylvania legislature, one of the proudest moments in my life was when one of the legislators was saying something about, "well, we don't really know if this is like a problem." And then another legislator said, "what do you mean? Didn't you see those graphs? Didn't you see how all those lines sloped down?" Wow, you know? They got it. And that's kind of the – I guess that that took priority at that point.

And also, we're just short-staffed, you know? At that point we were doing the acid rain thing, I was teaching full-time, trying to run this program, it's just crazy, I just didn't have time or I didn't choose to take the time away from maybe the building of the organization or the efficient running of the organization or the communication with volunteers, all the other things that we did. We also did a lot of community talks, about once a month we were going out into the community and giving talks about our work and about acid deposition, and that became the priority, rather than writing something up and putting it into the scientific literature. Although in retrospect, I kind of wish we had done that. And I wish we had enough resources to do that or maybe we had prioritized things a little bit differently, because I do think it's really important. And I do think that that would have been valuable, not only to share the stuff with the scientific community, which is always valuable, but also in terms of promoting volunteer monitoring as a means to collect valid scientific data. And that's the only way you can really do it is by getting peer-reviewed scientists saying, "yeah, this is good." And the other thing, too, is back in the acid rain days when I feel like we really had something to say to the scientific community, they were very wary of volunteer monitoring data. I really feel like we've come a long way in terms of the scientific community recognizing that all data of known quality is worthwhile, and as long as we know the quality and there's been quality control and quality assurance plans in place and so on and so forth, the data can be useful, and the data are valid for what they are. And the scientific community is much more open to that, I think, than they were in the early days.

And it's not that there isn't research – I mean, I have these slides that I did recently, and one is the three-legged stool of community science and research, education, and community empowerment or community work. For the model that we're using now with the Aquatic Resource Monitoring, the education I think is really strong, and the community problem solving aspect of it is really strong, but the research aspect is small. Whereas with the Acid Rain project, for the research aspect the leg was a little bit longer, community empowerment was pretty small, and education was sort of medium. That's the way I would put it. And I think for citizen science projects, you know, depending on what the project is, usually for citizen science projects the research leg is really strong. You know, or that point is really high. Whereas for what we're doing with ALLARM now, the research just isn't the primary goal. I mean, like for the Marcellus Shale monitoring that we're moving into now, we're not really researching the problem. What we're trying to do is we're trying to catch any spills and fix them. And we're also trying to make the companies aware that they're being watched. So, it's more of a political agenda, as well, and the results are, you know, community empowerment, sustainability, good education, I think in lots of ways. But research, not quite as strong.

I think that's appropriate. This is the model we've chosen, we've done it both ways and I, we just feel like this model has a stronger impact on environmental mitigation, protection, and so on. That this model, I mean, if I were a research scientist, I probably wouldn't be very comfortable with this model. But I'm not a research scientist and I'm very comfortable with this model because I'm interested in seeing social change, and I'm interested in seeing public education. And I feel that this model feeds into that interest.